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(54) Title: ENCODING APPARATUS FOR ENCODING A PLURALITY OF INFORMATION SIGNALS

(57) Abstract

An apparatus for encoding a plurality of n digital information signals is provided with at least a first, second and third input terminal (1, 2, 3) for receiving a first, a second and a third digital information signal (L, R, C). A matrixing unit (10) is provided for generating a first and a second digital composite signal (L_0, R_0) from the at least first, second and third digital information signals. First and second data compression means (22.1, 22.2) are provided for data compressing the first and second composite signals (L_0, R_0) so as to obtain first and second data reduced digital composite signals. A first selection unit (16) is provided for selecting at least one information signal from said plurality of n information signals so as to obtain at least a first auxiliary signal (AUX_1). At least a third data compression means (22.3) is present for data compressing the at least first auxiliary signal so as to obtain a first data reduced auxiliary signal. A formatting unit (24) is present for combining the first and second data reduced composite signals and the at least first data reduced auxiliary signal into a transmission signal suitable for transmission via a transmission medium. The apparatus further comprises at least first, second and third masked threshold determining means (26.1, 26.3, 26.4) for determining first (mt_L), second (mt_C) and third (mt_{L0}) masked thresholds respectively. A second selection unit (28.1) is provided for deriving one masked threshold from at least the first (mt_L) and third (mt_{L0}) masked threshold so as to obtain a first selected masked threshold (mt_L). Preferably, said first selected masked threshold is the smallest of the said at least first (mt_L) and third (mt_{L0}) masked threshold.

Encoding apparatus for encoding a plurality of information signals.

The invention relates to an encoder apparatus for encoding a plurality of digital information signals into a transmission signal and to a method for encoding the plurality of digital information signals. An encoder apparatus in accordance with the opening paragraph is known from EP 678,226-A1, which is document (8) in the list of related documents at the end of this description.

Matrixing can be carried out when transmitting a first main signal component (the left hand signal component L of a stereo signal), a second main signal component (the right hand signal component R) and an auxiliary component (a central signal component C), such that a first composite signal component L_0 is obtained which equals $L + a.C$ and a second composite signal R_0 is obtained which equals $R + b.C$, and where the signals L_0, R_0 and C are transmitted. Upon reception by a standard receiver not being provided with a corresponding dematrixing circuit, the signal components L_0 and R_0 are used for supplying via two stereo loudspeakers to a listener. The listener is thus able to perceive the C component transmitted as well, although he has a standard receiver.

More sophisticated matrixing schemes are discussed in J.A.E.S., Vol. 40, No. 5, May 1992, pp. 376-382, as well as in the publication 'Matrixing of bitrate reduced audio signals' by W.R.Th. ten Kate et al, in Proc. of the ICASSP, 1992, March 23-26, San Francisco, Vol.2, pp. II-205 to II-208, documents (1a) and (1b) in the list of references, as well as document (8).

They all satisfy the requirement that, even if a 4-channel (R, L, C and S) signal, or a 5-channel (L, R, C, LS, RS) signal is transmitted, the transmitted signal can be decoded by a standard stereo receiver.

Compression means for bit rate reducing a signal has been described in published European patent applications 457,390A1 (PHN 13.328) and 457,391A1 (PHN 13.329), the documents (7a) and (7b) respectively in the list of references. Further, reference is made to two ISO/IEC standard documents, the documents (9) and (10) in the list of related documents, referred to as MPEG-1 and MPEG-2 standard documents respectively.

The invention aims at providing further improvements to an encoder apparatus for encoding a plurality of information signals.

In accordance with the invention, the encoding apparatus for encoding a plurality of n digital information signals, having

5 - first input means for receiving a first digital information signal,

   - second input means for receiving a second digital information signal,

   - third input means for receiving a third digital information signal,

   - matrixing means for generating a first and a second digital composite signal from at least the first, second and third digital information signals,

10 - first and second data compression means for data compressing the first and second composite signal so as to obtain first and second data reduced digital composite signals, in response to first and second instruction signals respectively,

   - first selection means for selecting at least one information signal from said plurality of n information signals so as to obtain at least a first auxiliary signal,

15 - at least a third data compression means for data compressing the at least first auxiliary signal respectively so as to obtain a first data reduced auxiliary signal, in response to a third instruction signal,

   - formatting means for combining the first and second data reduced composite signals and the at least first data reduced auxiliary signal into a transmission signal suitable for transmission

20 via a transmission medium, characterized in that the apparatus further comprises

   - at least first, second and third masked threshold determining means for determining a first masked threshold from the first digital information signal, a second masked threshold from the third digital information signal and a third masked threshold from a combination of at least the first and the third digital information signal, respectively,

25 - second selection means for deriving one masked threshold from the third masked threshold and at least one other masked threshold so as to obtain a first selected masked threshold,

   - first instruction signal generator means for generating the first instruction signal in response to said first selected masked threshold, wherein n is an integer for which holds that n is larger than 2.

30   The invention is based on the following recognition. The invention resides in the objective to provide an n-channel encoder apparatus, which is backwards compatible so as to enable not only n-channel decoding, but also enables a 2-channel decoding using prior art MPEG-2 and MPEG-1 decoders respectively. Such encoder apparatus is meant to encode the three or more information signals introduced above, namely the signals for a left front

loudspeaker, a right front loudspeaker and a center loudspeaker, and in the case of a 4-channel signal a surround signal component, and in the case of a 5-channel signal a left surround signal for a left rear (surround) loudspeaker and a right surround signal for a right rear (surround) loudspeaker. The encoding must be realized such that decoding by a standard
5   stereo decoder will result in the generation of a compatible stereo signal.

During decoding sometimes an noise component became audible. Investigations resulted in the recognition that those noise components became audible because of the matrixing process in the encoder and the corresponding dematrixing process in the decoder. More specifically, the noise components originated from quantisation noise that could not be
10   masked anymore. By selecting another masked threshold to steer (control) the quantisation process, this problem can be solved. More specifically, during encoding an information signal, a choice is made for the masked threshold with which the information signal in question must be data reduced. The choice is made between at least two masked thresholds. For each signal to be data compressed one can say that, one of the at least two masked
15   thresholds is the masked threshold derived from the information signal to be data compressed itself and one of which is the masked threshold derived from another information signal.

In this way, an encoding and subsequent decoding can be realized such that upon decoding the replicas of the original signals as well as the replicas of the compatible signals are devoid of any audible quantisation noise.
20

These and other aspects of the invention will be apparent from and elucidated further with reference to the embodiments described in the following figure description, in which
25   figure 1 shows a part of a first embodiment of the encoder apparatus in accordance with the invention, for encoding a 3-channel information signal,

figure 2 shows a further part of the encoder apparatus of figure 1,

figure 3 shows a decoder apparatus for decoding the transmission signal obtained with the encoder apparatus of the figures 1 and 2,
30   figure 4 shows a modified version of the encoder apparatus of the figures 1 and 2,

figure 5 show a another modification to the encoder apparatus of the figures 1 and 2,

figure 6 shows again another modification of the encoder apparatus of the

figures 1 and 2,

figure 7 shows a part of a second embodiment of the encoder apparatus in accordance with the invention, for encoding a 4-channel information signal,

figure 8 shows a further part of the encoder apparatus of figure 7.

figure 9 shows another embodiment of the encoder apparatus for encoding a 4-channel information signal,

figure 10 shows a part of an encoder apparatus for encoding a 5-channel information signal,

figure 11 shows another part of the encoder apparatus of figure 10, and

figure 12 shows the encoder apparatus included in a recording apparatus.

I. A 3-channel encoder apparatus

The figures 1 and 2 show each a portion of a first embodiment of the encoder apparatus for encoding a 3-channel information signal, such as comprising the left hand signal component (L), the right hand signal component (R) and the centre signal component (C) of a 3-channel audio signal. The encoder apparatus comprises a first input terminal 1 for receiving the first information signal component (L), a second input terminal 2 for receiving the second information signal component (R) and a third input terminal 3 for receiving the third information signal component C. The three input terminals 1, 2 and 3 are each coupled to a corresponding input of a matrixing unit 10. The matrixing unit has two outputs 12 and 14 for supplying a first composite signal L_0 and a second composite signal R_0. The composite signals have the following relationship with the signals L, R and C:

$$L_0 = L + a.C \qquad \text{(Eq. 1a)}$$
$$R_0 = R + b.C \qquad \text{(Eq. 1b)}$$

where a and b are constants for which holds that they both are smaller than or equal to 1. Let us assume for the moment that $a = b = 1$.

The input terminals are also coupled to respective inputs of a first selection unit 16. This selection unit 16 selects one of the signals applied to its inputs under the influence of a selection signal applied to the terminal 18 and supplies the selected signal as a first auxiliary signal AUX_1 to its output 20. Three data compression units 22.1, 22.2 and 22.3 are provided for carrying out a data compression step on the signals L_0, R_0 and AUX_1

respectively. The data compression units 22.1 and 22.2 have their inputs coupled to the outputs 12 and 14 of the matrixing unit 10 and the data compression unit 22.3 has its input coupled to the output of the selection unit 16. Outputs of the data compression units 22.1, 22.2 and 22.3 are coupled to corresponding inputs of a signal combination unit 24.

The signal combination unit 24 combines the data compressed signals supplied by the data compression units 22.1, 22.2 and 22.3 into a serial datastream. Error correction encoding and channel encoding can be carried out on the serial datastream so as to obtain a transmission signal suitable for transmission via a transmission medium TRM. The transmission medium can be in the form of a record carrier, such as a magnetic or optical record carrier, or any other transmission medium, such as a digital audio broadcast channel (DAB).

Document (5) in the list of related documents describe one way of channel encoding the serial datastream so as to obtain the transmission signal. Preferably, the transmission signal is in accordance with the ISO/IEC standards given in documents (9) and (10).

Prior art publications describe the way in which a data compression step can be carried out on a signal applied to a data compression unit, such as the units 22.1, 22.2 and 22.3. One such data compression technique is the subband coding data compression technique, as applied in MPEG-1, MPEG-2 and DAB. Documents describing the subband coding data compression technique are the documents (3), (4), (6), (7a), (7b), (9) and (10). In this data compression technique, signal components below a masked threshold are left out, as one way of realizing the data compression. The data compression in the data compression units 22.1, 22.2 and 22.3 is realized in response to instruction signals is_1, is_2 and is_3 respectively, as shown in figure 1. Those instruction signals have been derived from masked thresholds to be discussed hereafter.

The apparatus further comprises five masked threshold determining units, denoted 26.1 to 26.5. The masked threshold determining unit 26.1 receives the first information signal L and derives a masked threshold therefrom and supplies the masked threshold as a first masked threshold mt_L to its output. The masked threshold determining unit 26.2 receives the second information signal R and derives a masked threshold therefrom and supplies the masked threshold as a second masked threshold mt_R to its output. The masked threshold determining unit 26.3 receives the third information signal C and derives a masked threshold therefrom and supplies the masked threshold as a third masked threshold mt_C to its output. The masked threshold determining unit 26.4 receives the first composite

signal L_0 and derives a masked threshold therefrom and supplies the masked threshold as a fourth masked threshold mt_{L0} to its output. The masked threshold determining unit 26.5 receives the second composite signal R_0 and derives a masked threshold therefrom and supplies the masked threshold as a fifth masked threshold mt_{R0} to its output.

5   One additional remark should be made here, as regards the derivation of the masked thresholds mt_{L0} and mt_{R0} in the units 26.4 and 26.5 respectively. As can be seen in figure 2, the input signals for the masked threshold determining units 26.4 and 26.5 have not been derived from the outputs 12 and 14 respectively of the matrixing unit 10, but by separately combining L and C so as to derive L_0 and R and C so as to derive R_0. In the embodiment later described with situation 1a one could have coupled the inputs of the units 26.4 and 26.5 directly to the outputs 12 and 14 respectively of the matrixing unit 10. In another embodiment, later described with situation 1b, where prequantisation and subsequent dequantisation is carried out on the auxiliary signal aux_1 prior to matrixing, the masked thresholds mt_{L0} and mt_{R0} should be derived from the original versions of L, R and C and not from the prequantised and subsequently dequantised version of one of such signals.

15   The apparatus further comprises three selection units 28.1, 28.2 and 28.3. The selection unit 28.1 receives a plurality of masked thresholds to its inputs and derives a first selected masked threshold mt_1 therefrom. Preferably, the selection unit 28.1 selects one of those plurality of masked thresholds as the first selected masked threshold mt_1 and supplies this first selected masked threshold mt_1 to its output. The selection unit 28.2 receives a plurality of masked thresholds to its inputs and derives a second selected masked threshold mt_2 therefrom. Preferably, the selection unit 28.2 selects one of those plurality of masked thresholds as the second selected masked threshold mt_2 and supplies this second selected masked threshold mt_2 to its output. The selection unit 28.3 receives a plurality of masked thresholds to its inputs and derives a third selected masked threshold mt_3 therefrom. Preferably, the selection unit 28.3 selects one of those plurality of masked thresholds as the third selected masked threshold mt_3 and supplies this third selected masked threshold mt_3 to its output.

      Outputs of the selection units 28.1, 28.2 and 28.3 are coupled to a corresponding input of respective instruction signal generator units 30.1, 30.2 and 30.3. Each instruction signal generator unit 30.i (where i runs from 1 to 3) generates an instruction signal in response to a selected masked threshold supplied to its input. More specifically, the instruction signal generator unit 30.1 calculates a signal-to-mask ratio between the signal L_0 and the masked threshold supplied by the selection unit 28.1 and subsequently derives

bitallocation information therefrom, in a way well known in the prior art. This bit allocation information is used to quantize the signal L_0 in the data compression unit 22.1. In the same way, the instruction signal generator unit 30.2 calculates a signal-to-mask ratio between the signal R_0 and the masked threshold supplied by the selection unit 28.2 and subsequently derives bitallocation information therefrom. This bit allocation information is used to quantize the signal R_0 in the data compression unit 22.2. In the same way, the instruction signal generator unit 30.3 calculates a signal-to-mask ratio between the signal AUX_1 and the masked threshold supplied by the selection unit 28.3 and subsequently derives bitallocation information therefrom. This bit allocation information is used to quantize the signal AUX_1 in the data compression unit 22.3.

The selection made in the selection unit 16, of which of the three input signals will become the auxiliary signal, is based on the amount of data compression that can be obtained. This has been described in various earlier documents, such as the documents (2) and (8). One way of selecting the first auxiliary signal is based on the following requirement. That one signal of the three signals L, R and C is chosen as the auxiliary signal AUX_1 that results in the highest data compression ratio to be achieved in the data compression units 22.1, 22.2 and 22.3. It will be clear that the apparatus thus comprise a calculation unit 32 that generates, in accordance with the above requirement, the selection control signal tca for the selection unit 16.

Before describing the derivation of the masked thresholds in the selection units 28.1, 28.2 and 28.3, a decoder apparatus for decoding the 3-channel information signal will be described.

Figure 3 shows a decoder for receiving and decoding the compressed signals transmitted by the transmitter of the figures 1 and 2 via the transmission medium TRM. This description can also be found in document (8) of the list of related documents.

The serial datastream is applied to an input 40 of a demultiplexer 41, which splits the information in the serial datastream into the original quantized samples of the signal L_0, which samples are applied to an output 43, the original quantized samples of the signal R_0, which samples are applied to an output 101, the original quantized samples of the first auxiliary signal AUX_1 transmitted, which is either the quantized L-, R- or C-signal, which samples are applied to an output 44. The first, second and third instruction signals is_1, is_2 and is_3 are transmitted as well and thus retrieved from the serial datastream by the demultiplexer 41. The first instruction signal is_1 is applied to an output 42, the second instruction signal is_2 is applied to an output 102 and the third instruction signal is_3 is applied

to an output 45. The outputs 43, 44 and 101 are coupled to signal inputs of data expansion units (dequantizers DEQ) 48, 49 and 50 respectively. The outputs 42, 45 and 102 are coupled to control signal inputs of the quantizers 48, 49 and 50 respectively, so as to enable the instruction signals to be applied to the dequantizers. The dequantizer 48 generates a

5   replica L_0' of the signal L_0, which is supplied to an output 51. The dequantizer 50 generates the replica R_0' of the signal component R_0, which is supplied to an output 53. The dequantizer 49 generates a replica AUX_1' of the quantized first auxiliary signal AUX_1 which is applied to the output 52. The outputs 51, 52 and 53 are coupled to inputs 55, 56 and 58 respectively of a dematrixing unit 57.

10   The demultiplexer means 41 has an additional output 120 for supplying a control signal equivalent to the tca control described with reference to figure 1. The dematrixing unit 57 has an additional control signal input 121 which is coupled to the output 120 of the demultiplexer means 41. If the control signal tca applied to the control signal input 121 has a first value, this means that the signal applied to the input 56 of the

15   dematrixing unit 57 is the replica of the C-signal. In that case, the dematrixing unit 57 functions so that replicas of the L- and R-signals are applied to outputs 105 and 106 respectively, and thus to terminals 60 and 125 respectively. If the control signal tca applied to the control signal input 121 has a second value, this means that the signal applied to the input 56 of the dematrixing unit 57 is the replica of the L-signal. In that case, the

20   dematrixing means 57 functions such that replicas of the C- and R-signals are applied to the outputs 105 and 106 respectively, and thus to the terminals 60 and 125 respectively. If the control signal tca applied to the control signal input 121 has a third value, this means that the signal applied to the input 56 of the dematrixing unit 57 is the replica of the R-signal. In that case, the dematrixing unit 57 functions such that replicas of the L- and C-signals are applied

25   to the terminals 60 and 125 respectively.

          The receiver further comprises a controllable switching unit 122 comprising switches 77, 123 and 78'. In response to a tca control signal of the first value applied to the switching means 122, the switch 77 is switched in the position a-b, the switch 123 is switched in the position a-b and the switch 78' is switched in the position b-d, so that the

30   replicas L', R' and C' are applied to the terminals 126, 127 and 128 respectively. In response to the tca control signal of the second value applied to the switching means 122, the switch 77 is switched in the position c-b, the switch 123 is switched in the position a-b and the switch 78' is switched in the position a-d, so that the replicas L', R' and C' are again applied to the terminals 126, 127 and 128 respectively. In response to the tca control signal

of the third value applied to the switching means 122, the switch 77 is switched in the position a-b, the switch 123 is switched in the position c-b and the switch 78' is switched in the position c-d, so that the replicas L', R' and C' are again applied to the terminals 126, 127 and 128 respectively.

The 3-channel information signal has been encoded in such a way into a transmission signal in the encoding apparatus of the figures 1 and 2, that it is backwards compatible. That means that prior art stereo decoders are also capable to decode the transmission signal into a 2-channel stereo audio signal. Those decoders solely retrieve the first and second data compressed composite signals L_0 and R_0 from the transmission signal, data expands them into the replicas L_0' and R_0' and supplies them to two loudspeakers positioned in a stereo setup in a room.

The replicas L_0' and R_0' satisfy the following equations:

$$L_0' = L_0 + N_{L0} \qquad \text{(Eq.2a)}$$
$$R_0' = R_0 + N_{R0} \qquad \text{(Eq.2b)}$$

where N_{L0} is the quantisation noise introduced by data compressing the signal L_0 using the instruction signal is_1 derived from the masked threshold mt_1 and N_{R0} is the quantisation noise introduced by data compressing the signal R_0 using the instruction signal is_2 derived from the masked threshold mt_2. The noise component N_{L0} is masked by the signal L_0 and the noise component N_{R0} is masked by the signal R_0, so that the quantisation noise in the signals L_0' and R_0' are unaudible.

Now, let us look at how the signals L, R and C are retrieved. It is assumed that $aux_1 = C$, or $tca = 0$. Thus:

$$C' = aux_1' = C + N_C.$$

N_C is the quantisation noise introduced by data compressing the signal C using the instruction signal is_3, which is derived from the masked threshold mt_3. The noise component N_C is masked by the signal C, so that the quantisation noise in the signal C' is inaudible.

The signals L and R are retrieved as:

$$L' = L_0' - C' = L + N_{L0} - N_C$$

$$R' = R_0' - C' = R + N_{R0} - N_C.$$

The signal part in L_0 which corresponds to C is removed. However, because in general N_{L0} and N_C are uncorrelated, the part in N_{L0} which corresponds to N_C remains and in fact might double in level. As a consequence, that part (N_C) might become audible in L'. The same reasoning is valid for the behaviour of N_C in R'.

In order to overcome this, the selection units 28.1, 28.2 and 28.3 are provided in the encoder apparatus.

The selection of the masked thresholds will now be described in full detail. It should be noted here already that the group of masked thresholds from which one masked threshold should be selected in a selection unit 28.i can be different in the various situations that can occur. Amongst others, the group of masked thresholds depends on which of the three signals has been chosen as the auxiliary signal AUX_1.

la

Table 1 below shows the three situations indicated by the three tca values tca=0, tca=1 and tca=2, and indicating the choice for the auxiliary signal AUX_1, which is the signal C, L and R respectively. When C is selected as the auxiliary signal, the signals L and R are denoted as first and second main signals M_1 and M_2 respectively. When L is selected as the auxiliary signal, the signals C and R are denoted as first and second main signals M_1 and M_2 respectively. When R is selected as the auxiliary signal, the signals L and C are denoted as first and second main signals M_1 and M_2 respectively.

Table 1

tca	M_1	M_2	AUX_1
0	L	R	C
1	C	R	L
2	L	C	R

Suppose first that the calculation unit 32 has established that the signal C should be selected as the auxiliary signal AUX_1. Thus tca=0.

The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R.

The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_C.

As the smallest of the masked thresholds mt_{L0} and mt_L is chosen for data compressing L_0, this means that no quantisation noise is audible in the regenerated signal L_0' upon decoding. In the same way, as the smallest of the masked thresholds mt_{R0} and mt_R is chosen for data compressing R_0, this means that no quantisation noise is audible in the regenerated R_0' upon decoding. Also in the same way, as the smallest of the masked thresholds mt_C, mt_L and mt_R is chosen for data compressing C, this means that no quantisation noise is audible in the regenerated C' upon decoding.

As said above, $L' = L_0' - C' = L + N_{L0} - N_C$. N_{L0} is masked by the masked threshold mt_1, which is the minimum of the masked thresholds mt_{L0} and mt_L. As a consequence, N_{L0} is also masked by the signal L. N_C is masked by the masked threshold mt_3, which is the minimum of the masked thresholds mt_C, mt_R and mt_L. As a consequence, N_C is also masked by the signal L.

An equivalent reasoning applies to the signal R'. As a consequence, all the signals that are regenerated in the decoder are free of quantisation noise.

Suppose now that $\underline{tca=1}$. The selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_R and mt_C. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{R0} and mt_R.

The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_C.

The quantisation noise in L_0 and R_0 is inaudible, for the same reasoning as given above for tca=0. For the signal aux_1 now holds the equation: $aux_1 = L' = L + N_L$. N_L is masked by the masked threshold mt_3, which is the minimum of mt_L, mt_C and mt_R. As a consequence, N_L is inaudible, as it is masked by mt_L.

For the regenerated signal C', the following equation holds:

$$C' = L_0' - L' = C + N_{L0} - N_L.$$

N_{L0} is masked by mt_1, which is the minimum of the masked thresholds mt_{L0}, mt_R and mt_C. Thus N_{L0} is also masked by C. N_L is masked by mt_3, which is the minimum of the masked thresholds mt_L, mt_C and mt_R. Thus N_L is also masked by C. As a consequence, C' is free from audible quantisation noise.

For the regenerated signal R', the following equation holds:

$$R' = R_0' - C' = R + N_{R0} - N_{L0} + N_L.$$

N_{R0} is masked by mt_2, which is the minimum of the masked thresholds mt_{R0} and mt_R. Thus N_{R0} is also masked by R. N_{L0} is masked by mt_1, which is the minimum of the masked thresholds mt_{L0}, mt_C and mt_R. Thus N_{L0} is also masked by R. N_L is masked by mt_3, which is the minimum of the masked thresholds mt_L, mt_C and mt_R. Thus N_L is also masked by R. As a consequence, R' is free from audible quantisation noise.

Suppose now that $tca = 2$. The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are now: $\hat{m}t_{R0}$, mt_L and mt_C.

The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are now: mt_L, mt_R and mt_C.

From an explanation that all the signals are free from audible quantisation noise, will be refrained, for the following reason. The situation $tca = 2$ can be obtained from the situation $tca = 1$, when interchanging R and L, L_0 and R_0 and mt_1 and mt_2. Therefore, an equivalent reasoning as given above for $tca = 1$ is valid for $tca = 2$, to prove that the regenerated signals are all free from audible quantisation noise.

Ib

In the foregoing, it has been assumed that no prequantisation and subsequent dequantisation has taken place on the first auxiliary signal AUX_1 prior to matrixing. Prequantisation and subsequent dequantisation on an auxiliary signal prior to matrixing has been described in various prior art documents and can result in a large saving in bitneed. Reference is made in this respect to the documents (2) and (8) in the list of related documents.

More specifically, figure 4 discloses schematically an embodiment of the

encoder apparatus embodying such prequantisation and subsequent dequantisation on the auxiliary signal AUX_1, prior to matrixing. As can be seen in figure 4, the encoder apparatus further comprises a data expansion unit 7 having an input coupled to the output of the data compression unit 22.3, in which the data compressed auxiliary signal AUX_1 is expanded so as to obtain a replica AUX_1' of the auxiliary signal. Further, a switching unit 111 is required to provide the matrixing unit 10' with all the signals needed for carrying out the matrixing step. The switching unit 111 comprises switches 70 and 110 controlled by the tca control signal. Further, the matrixing unit 10' now requires the reception of the control signal tca.

For tca = 0, both switches 70 and 110 are in their position a-b. For tca = 1, the switch 70 is in its position b-c and the switch 110 is in its position a-b. For tca = 3, the switch 70 is in its position a-b and the switch 110 is in its position b-c. The matrixing unit 10' now generates composite signals, designated L_{p0} and R_{p0}, which indicate that the composite signals comprise a component of the auxiliary signal that is quantised and subsequently dequantised. Further, as has been said above, the masked thresholds mt_{L0} and mt_{R0} given in figure 2 will be derived from the original signals. So, not the quantised and subsequently prequantised version of the signal selected as the auxiliary signal is used for obtaining the masked thresholds mt_{L0} and mt_{R0}.

For the embodiment of the encoder apparatus of figure 4, some of the selections described above will change.

More specifically, for _tca = 0_, the selections in the selection units 28.1 and 28.2 remain the same as described above for the situation 1a and tca = 0. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_{R0} and mt_C.

Again, it will be shown that replicas of all signals that can be regenerated in a decoder will be free of audible quantisation noise.

The regenerated replica of the signal L_{p0}, which is indicated L_{p0}' satisfies the following equation: $L_{p0}' = L_{p0} + N_{L0}$, where the quantisation noise component N_{L0} comes from the quantisation of L_{p0} in data compression unit 22.1 and the subsequent expansion in the data expander 48, see figure 3. Further, L_{p0} satisfies the equation: $L_{p0} = L + C + N_C$, where the quantisation noise component N_C comes from the quantisation of the signal C in the data compression unit 22.3 and the subsequent data expansion in data expander 7, see figure 4. Thus $L_{p0}' = L + C + N_C + N_{L0}$, or $L_{p0}' = L_0 + N_C + N_{L0}$.

N_{L0} stems from mt_1, which is the minimum of mt_{L0} and mt_L. Thus, N_{L0} is thus masked by L_0. N_C stems from mt_3, which is the minimum of mt_C, mt_{L0} and mt_{R0}. Thus, N_C

is also masked by L_0. Or, L_{p0}' is free from audible quantisation noise. An equivalent reasoning can be held for R_{p0}'.

The replica C' equals $C + N_C$. As said above, N_C stems from mt_3, which is the minimum of mt_C, mt_{L0} and mt_{R0}. Thus, N_C is masked by C and C is thus free from audible quantisation noise.

The replica L' satisfies the following equation: $L' = L_{p0}' - C'$, which is equal to: $L' = L + N_{L0}$. As said above, N_{L0} stems from mt_1, which is the minimum of mt_{L0} and mt_L. Thus, N_{L0} is masked by L, as well, and L' is free from audible quantisation noise.

For $\underline{tca = 1}$, the selections in the selection units 28.1 and 28.2 again remain the same as described above for the situation 1a and $tca = 1$. The selection unit 28.3, however, now selects the smallest masked threshold from a group of two masked thresholds, which are: mt_L and mt_{L0}.

No further explanation will be given. But, it will be clear that, using an equivalent reasoning as given above is possible, showing that all regenerated signals are free from audible quantisation noise.

For $\underline{tca = 2}$, the selections in the selection units 28.1 and 28.2 again remain the same as described above for the situation 1a and $tca = 2$. The selection unit 28.3, however, now selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{R0}.

1c

A further variation in the case of $tca = 0$, is to derive the two composite signals in the following way in the matrixing unit 10:

$$L_{p0} = L + C_{pd} \qquad\qquad (Eq.3a)$$
$$R_0 = R + C \qquad\qquad (Eq.3b)$$

This means that L_{p0} is derived from C_{pd}, which is a prequantised and subsequently dequantised version of C, whereas R_0 is derived from the original signal C.

For $\underline{tca = 0}$, the selections in the selection units 28.1 and 28.2 again remain the same as described above for the situation 1a and $tca = 0$. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R and mt_C.

Id

Again another variation in the case of tca=0, is to derive the composite signals in the following way in the matrixing unit 10:

$$L_0 = L + C \qquad\qquad\qquad (Eq.4a)$$

$$R_{p0} = R + C_{pd} \qquad\qquad\qquad (Eq.4b)$$

This means that R_{p0} is derived from C_{pd}, which is the prequantised and subsequently dequantised version of C, whereas L_0 is derived from the original signal C.

For tca=0, the selections in the selection units 28.1 and 28.2 again remain the same as described above for the situation Ia and tca=0. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{R0} and mt_C.

le

When tca=1 is chosen, it is known from a prior art document, document (8) in the list of related documents, to carry out a compensation on the second composite signal R_0. This is shown in figure 5. Also, reference is made in this respect to figure 11 and the corresponding description in the document (8).

In this situation, the selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_{R0} and mt_C.

If

When tca=2 is chosen, it is known from a prior art document, document (8) in the list of related documents, to carry out a compensation on the first composite signal L_0. This is shown in figure 6. Also, reference is made in this respect to figure 12 and the corresponding description in the document (8).

In this situation, the selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_{R0} and mt_C.

Table 2 comprises all selections of the masked thresholds in the three selection

units 28.1, 28.2 and 28.3 for the situations described above.

Table 2

situation	tca	28.1	28.2	28.3
Ia	0	mt_{L0}, mt_L	mt_{R0}, mt_R	mt_L, mt_R, mt_C
	1	mt_{L0}, mt_C, mt_R	mt_{R0}, mt_R	mt_L, mt_R, mt_C
	2	mt_{L0}, mt_L	mt_{R0}, mt_C, mt_L	mt_L, mt_R, mt_C
Ib	0			mt_{L0}, mt_{R0}, mt_C
	1			mt_L, mt_{L0}
	2			mt_R, mt_{R0}
Ic	0			mt_{L0}, mt_R, mt_C
Id	0			mt_L, mt_{R0}, mt_C
Ie	1	mt_{L0}, mt_{R0}, mt_C		
If	2		mt_{L0}, mt_{R0}, mt_C	

It should be noted here that the masked thresholds in the positions not filled in in the table 2 for the situations Ib to If are identical to the masked thresholds filled in in the corresponding positions in the situation Ia. Further, when combining the situations Ib and Ie (or the situations Ib and If), the selections given under Ie (If) should replace the selections given in Ib.

From table 2 it is clear that the selection unit 28.1 requires at least the masked thresholds mt_L and mt_{L0} for the selection. Further, in the situation Ia and tca=1, also mt_C and mt_R are required for carrying out the selection. Moreover, if the apparatus is also provided with the circuit shown in figure 5, that is the situation Ie and tca=1, in addition mt_{R0} is required for carrying out the selection. Figure 2 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.5 and the selection unit 28.1. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, the masked thresholds given in the table will be supplied to the selection unit 28.1.

It is further clear from the table 2 that the selection unit 28.2 requires at least

the masked thresholds mt_R and mt_{R0} for carrying out a selection. Further, in the situation Ia and tca=2, also mt_L and mt_C for carrying out the selection. Moreover, if the apparatus is provided with the circuit shown in figure 6, that is the situation If and tca=2, in addition the masked threshold mt_{L0} is required. Figure 2 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.5 and the selection unit 28.2. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, the masked thresholds given in the table will be supplied to the selection unit 28.2.

In the same way, figure 2 shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.5 and the selection unit 28.3. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, the masked thresholds given in the table will be supplied to the selection unit 28.3.

II. A 4-channel encoder apparatus

The figures 7 and 8 show an embodiment of a encoder apparatus for encoding a 4-channel information signal, such as a 4-channel audio signal comprising the left hand signal component (L), the right hand signal component (R), the centre signal component (C) and a surround signal component (S). The encoder apparatus shows large resemblances with the encoder apparatus of the figures 1 and 2. Apart from the elements already discussed with reference to the figures 1 and 2, the embodiment of the figures 7 and 8 comprise a fourth input terminal 4 for receiving a fourth information signal in the form of the surround signal S. The input terminal 4 is coupled to a corresponding input of the matrixing unit 10.2. The matrixing unit 10.2 has two outputs 12 and 14 for supplying a first composite signal L_0 and a second composite signal R_0. The composite signals have the following relationship with the signals L, R, C and S:

$$L_0 = L + a.C + d.S \qquad (Eq. 5a)$$
$$R_0 = R + b.C + f.S \qquad (Eq. 5b)$$

where a, b, d and f are constants for which holds that they all are smaller than or equal to 1. Let us assume for the moment that a=b=d=f=1.

The input terminal 4 is also coupled to a corresponding input of the first

selection unit 16.1. This selection unit 16.1 selects two of the signals applied to its four inputs under the influence of a selection signal tca' applied to the terminal 18 and supplies the selected signals as first and second auxiliary signals AUX_1 and AUX_2 respectively, to its outputs 20.1 and 20.2 respectively. A fourth data compression unit 22.4 is provided for

5   carrying out a data compression step on the signals AUX_2. The data compression unit 22.3 has its input coupled to the output 20.1 of the selection unit 16.1 and the data compression unit 22.4 has its input coupled to the output 20.2 of the selection unit 16.1. Outputs of the four data compression units 22.1 to 22.4 are coupled to corresponding inputs of a signal combination unit 24.1.

10   The signal combination unit 24.1 combines the data compressed signals supplied by the data compression units 22.1, 22.2, 22.3 and 22.4 into a serial datastream, in the same way as described above.

         The apparatus now comprises six masked threshold determining units, denoted 26.1 to 26.6. The masked threshold determining units 26.1 to 26.3 are identical to the three

15   masked threshold determining units 26.1 to 26.3 described above with reference to the figures 1 and 2. The fourth masked threshold determining unit 26.4 now receives a combination of the signals L, C and S, more specifically a signal that equals L+C+S, and derives the masked threshold mt_{L0} therefrom. The fifth masked threshold determining unit 26.5 now receives a combination of the signals R, C and S, more specifically a signal that

20   equals R+C+S, and derives a masked threshold mt_{R0} therefrom. The sixth threshold determining unit 26.6 receives the fourth information signal S and derives a masked threshold therefrom and supplies the masked threshold as a sixth masked threshold mt_S to its output.

         It should be noted here, that in one of the situations to be described later, the

25   input signal for the masked threshold determining unit 26.5 will be equal to R+C-S.

         The apparatus now comprises four selection units 28.1, 28.2, 28.3 and 28.4. The selection units all receive a plurality of masked thresholds to their respective inputs and each select one of those plurality of masked thresholds as a selected masked threshold to its output. In this way, the selection unit 28.4 receives a plurality of masked thresholds to its

30   inputs and selects one of those plurality of masked thresholds so as to obtain a fourth selected masked threshold mt_4 and supplies this second selected masked threshold mt_4 to its output.

         Outputs of the selection units 28.1, 28.2, 28.3 and 28.4 are coupled to a corresponding input of respective instruction signal generator units 30.1, 30.2, 30.3 and 30.4. Each instruction signal generator unit 30.i (where i runs from 1 to 4) generates an

instruction signal in response to a masked threshold supplied to its input in a way described above. In this way, the instruction signal generator unit 30.4 calculates a signal-to-mask ratio between the signal AUX_2 and the masked threshold supplied by the selection unit 28.4 and subsequently derives bitallocation information therefrom. This bit allocation information is

5   used to quantize the signal AUX_2 in the data compression unit 22.4.

The selection made in the selection unit 16.1, of which two of the four input signals will become the first and second auxiliary signals, is based on the amount of data compression that can be obtained. This has been described in various earlier documents, such as the documents (2) and (8). Generally said, that selection of two out of the four input

10   signals will be made that leads to the highest data reduction that can be obtained. It will be clear that the apparatus therefore comprises a calculation unit 32.1 that generates the selection control signal tca' for the selection unit 16.1.

A selection between two or more masked thresholds is required, as explained above, in order to avoid that, upon decoding in the decoder, the quantisation noise present in

15   any of the regenerated signals L', R', C', S', L_0' and R_0' become audible.

The selection of the masked thresholds will now be described in detail. It should be noted here already that the group of masked thresholds from which one masked threshold should be selected in a selection unit 28.i can be different in the various situations that can occur. Amongst others, the group of masked thresholds depends on which of the

20   four signals have been chosen as the auxiliary signals AUX_1 and AUX_2.

IIa

Table 3 below shows six situations indicated by the six tca' values tca=0 to

25   tca=5, and indicating the choices for the auxiliary signals AUX_1 and AUX_2. When C and S are selected as the auxiliary signals (tca'=0), the signals L and R are denoted as first and second main signals M_1 and M_2 respectively. When L and S are selected as the auxiliary signals (tca'=1), the signals C and R are denoted as first and second main signals M_1 and M_2 respectively. When R and S are selected as the auxiliary signals (tca'=2), the signals L

30   and C are denoted as first and second main signals M_1 and M_2 respectively. When C and L are selected as the auxiliary signals (tca'=3), the signals S and R are denoted as first and second main signals M_1 and M_2 respectively. When C and R are selected as the auxiliary signals (tca'=4), the signals L and S are denoted as first and second main signals M_1 and M_2 respectively. When L and R are selected as the auxiliary signals (tca'=5), the signals S

and C are denoted as first and second main signals M_1 and M_2 respectively.

Table 3

tca'	M_1	M_2	AUX_1	AUX_2
0	L	R	C	S
1	C	R	L	S
2	L	C	R	S
3	S	R	C	L
4	L	S	C	R
5	C	S	L	R

It should be noted here that the situation indicated by tca'=5 is only possible for f=-d and b=a, see the eq.5b given above. Thus, in the present example, f=-1.

Suppose first that the calculation unit 32.1 has established that the signals C and S should be selected as the auxiliary signals AUX_1 and AUX_2. Thus tca'=0.

The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_S.

No further explanation will be given to show that all signals regenerated are free from audible quantisation noise.

Suppose now that tca'=1. The selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_C and mt_R. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{R0} and mt_R. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_C and mt_S.

Suppose now that tca'=2. The selection unit 28.1 will now select the smallest

masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are now: mt_{R0}, mt_C and mt_L. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are now: mt_L, mt_R and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are now: mt_C and mt_S.

Suppose now that $\underline{tca'=3}$. The situation $tca'=3$ can be obtained from the situation $tca'=1$ by interchanging S and C. Thus, the selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_S and mt_R. The selection unit 28.2 will select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{R0} and mt_R. The selection unit 28.3 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_C and mt_S. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are again: mt_R, mt_L and mt_S.

The situation $\underline{tca'=4}$ can be obtained from the situation $tca'=2$ by interchanging S and C. Thus, the selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{R0}, mt_S and mt_L. The selection unit 28.3 selects the smallest masked threshold from a group of two masked thresholds, which are again: mt_C and mt_S. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are again: mt_L, mt_R and mt_S.

As has been explained above, the situation $\underline{tca'=5}$ is only possible if the following equations hold for L_0 and R_0:

$$L_0 = L + a.C + d.S \qquad \text{(Eq.6a)}$$
$$R_0 = R + a.C - d.L \qquad \text{(Eq.6b)}$$

Upon decoding the replicas C' and S' of the signals C and S can be obtained from:

$$C' = 0.5\{(L_0' + R_0') - (L' + R')\}/a \qquad \text{(Eq.7a)}$$
$$S' = 0.5\{(L_0' - R_0') - (L' - R')\}/d \qquad \text{(Eq.7b)}$$

Again, we assume that $a = d = 1$. The selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are again: mt_{L0}, mt_C and mt_S. The selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{R0}, mt_C and mt_S. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_C and mt_S. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_R, mt_C and mt_S.

IIb

In the foregoing, it has been assumed that no prequantisation and subsequent dequantisation has taken place on the first auxiliary signal AUX_1 and/or the second auxiliary signal AUX_2, prior to matrixing. Prequantisation and subsequent dequantisation on an auxiliary signal prior to matrixing has been described in various prior art documents. Reference is made in this respect to the documents (2) and (8) in the list of related documents.

More specifically, figure 9 discloses schematically an embodiment of the encoder apparatus embodying such prequantisation and subsequent dequantisation on the auxiliary signals AUX_1 and AUX_2, prior to matrixing. As can be seen in figure 9, the encoder apparatus further comprises data expansion units 7.1 and 7.2, having inputs coupled to the outputs of the respective data compression units 22.3 and 22.4. The data expansion units 7.1 and 7.2 expand the data compressed auxiliary signals AUX_1 and AUX_2 so as to obtain replicas AUX_1' and AUX_2'. Further, a switching unit 111.1 is required to provide the matrixing unit 10 with all the signals needed for carrying out the matrixing step. The switching unit 111.1 comprises switches 70.1 and 110.1 controlled by the tca' control signal. Further, the matrixing unit 10.2' now requires the reception of the control signal tca'.

For tca'=0, both switches 70.1 and 110.1 are in their position a-b. For tca'=1, the switch 70.1 is in its position b-c and the switch 110.1 is in its position a-b. For tca'=2, the switch 70.1 is in its position a-b and the switch 110.1 is in its position b-c. For tca'=3, the switch 70.1 is in its position b-d and the switch 110.1 is in its position a-b. For tca'=4, the switch 70.1 is in its position a-b and the switch 110.1 is in its position b-d. For tca'=5, the switch 70.1 is in its position b-c and the switch 110.1 is in its position b-d. The matrixing unit 10.2' now generates composite signals, designated L_{p0} and R_{p0}, which indicate that the composite signals comprise a component of the two auxiliary signals that

have been quantised and subsequently dequantised. Further, as has been said above, the masked thresholds mt_{L0} and mt_{R0} given in figure 8 will be derived from the original signals. So, not the quantised and subsequently prequantised versions of the signals selected as the auxiliary signal are used for obtaining the masked thresholds mt_{L0} and mt_{R0}.

For the embodiment of the encoder apparatus of figure 9, some of the selections described above will change.

More specifically, for $tca'=0$, the selection unit 28.1 selects between the masked thresholds mt_{L0} and mt_L and the selection unit 28.2 selects between the masked threshold mt_{R0} and mt_R. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_{R0} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_{R0} and mt_S.

No further explanation will be given that the selection of the masked thresholds leads to an inaudible quantisation noise in the various signals retrieved in a receiver.

For $tca'=1$, the selection unit 28.1 selects between the masked thresholds mt_{L0}, mt_C and mt_R and the selection unit 28.2 selects between the masked thresholds mt_{R0} and mt_R. The selection unit 28.3 now selects the smallest masked threshold from a group of two masked thresholds, which are: mt_L and mt_{L0}. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0}, mt_{L0} and mt_S.

For $tca'=2$, the selection unit 28.1 selects between the masked thresholds mt_{L0} and mt_L and the selection unit 28.2 selects between the masked thresholds mt_{R0}, mt_C and mt_L. The selection unit 28.3 now selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{R0}. The selection unit 28.4 now selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0}, mt_{R0} and mt_S.

For $tca'=3$, the selection unit 28.1 selects between the masked thresholds mt_{L0}, mt_S and mt_R. The selection unit 28.2 selects between the masked thresholds mt_{R0} and mt_R. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_{R0} and mt_C. The selection unit 28.4 now selects the smallest masked threshold from the masked thresholds mt_{L0} and mt_L.

For $tca'=4$, the selection unit 28.1 will select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0}, mt_S and mt_L. The selection unit 28.3 selects the smallest masked threshold

from a group of three masked thresholds, which are: mt_{L0}, mt_{R0} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are now: mt_{R0} and mt_R.

For $\underline{tca'=5}$, the selection unit 28.1 will select the smallest masked threshold from a group of three masked thresholds, which are again: mt_{L0}, mt_C and mt_S. The selection unit 28.2 will select the smallest masked threshold from a group of three masked thresholds, which are again mt_{R0}, mt_C and mt_S. The selection unit 28.3 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{R0} and mt_R.

IIc

A further variation of the embodiment described under the situation IIa, is to derive the two composite signals in the following way in the matrixing unit 10.2':

$$L_{p0} = L + C_{pd} + S \qquad \text{(Eq.8a)}$$
$$R_0 = R + C + S \qquad \text{(Eq.8b)}$$

This means that L_0 is derived from C_{pd}, which is a prequantised and subsequently dequantised version of C, and from the original signals L and S, whereas R_0 is derived from the original signals R, C and S.

For $\underline{tca'=0}$, the selections in the selection units 28.1, 28.2 and 28.4 remain the same as described for the situation IIa. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R and mt_C.

For $\underline{tca'=3}$, the selections in the selection units 28.1, 28.2 and 28.4 remain the same as described for the situation IIa. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R and mt_C.

For $\underline{tca'=4}$, the selections in the selection units 28.1, 28.2 and 28.4 remain the same as described for the situation IIa. The selection unit 28.3, however, now selects the smallest masked threshold from a group of four masked thresholds, which are: mt_{L0}, mt_L, mt_C and mt_S.

It should be noted that for the tca' values 1, 2 and 5, C is not selected as an auxiliary signal, and thus does not fit in this situation.

IId

A further variation of the embodiment described under the situation IIa, is to derive the two composite signals in the following way in the matrixing unit 10.2':

$$L_0 = L + C + S \qquad\qquad \text{(Eq.9a)}$$
$$R_{p0} = R + C_{pd} + S \qquad\qquad \text{(Eq.9b)}$$

This means that L_0 is derived from the original signals L, C and S, that are not prequantised and subsequently dequantised, whereas R_{p0} is derived from C_{pd} which is a prequantised and subsequently dequantised version of C and the original signals R and S.

For <u>tca'=0</u>, the selections in the selection units 28.1, 28.2 and 28.4 remain the same as described for the situation IIa. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{R0} and mt_C.

For <u>tca'=3</u>, the selections in the selection units 28.1, 28.2 and 28.4 remain the same as described for the situation IIa. The selection unit 28.3, however, now selects the smallest masked threshold from a group of four masked thresholds, which are: mt_{R0}, mt_R, mt_S and mt_C.

For <u>tca'=4</u>, the selections in the selection units 28.1, 28.2 and 28.4 remain the same as described for the situation IIa. The selection unit 28.3, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{R0} and mt_C.

It should be noted that for the tca' values 1, 2 and 5, C is not selected as an auxiliary signal, and thus does not fit in this situation.

IIe

A further variation of the embodiment described under the situation IIa, is to derive the composite signals in the following way in the matrixing unit 10.2':

$$L_{p0} = L + C + S_{pd} \qquad \text{(Eq.10a)}$$
$$R_0 = R + C + S \qquad \text{(Eq.10b)}$$

This means that L_0 is derived from S_{pd}, which is a prequantised and

5   subsequently dequantised version of S, and the original signals L and C, whereas R_0 is

derived from the original signals R, C and S.

For $\underline{tca'=0}$, the selections in the selection units 28.1, 28.2 and 28.3 remain the

same as described for the situation IIa. The selection unit 28.4, however, now selects the

smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R

10   and mt_S.

For $\underline{tca'=1}$, the selections in the selection units 28.1, 28.2 and 28.3 remain the

same as described for the situation IIa. The selection unit 28.4, however, now selects the

smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R

and mt_S.

15   For $\underline{tca'=2}$, the selections in the selection units 28.1, 28.2 and 28.3 remain the

same as described for the situation IIa. The selection unit 28.4, however, now selects the

smallest masked threshold from a group of four masked thresholds, which are: mt_{L0}, mt_L,

mt_C and mt_S.

It should be noted that for the tca' values 3, 4 and 5, S is not selected as an

20   auxiliary signal, and thus does not fit in this situation.

IIf

A further variation of the embodiment described under the situation IIa, is to

25   derive the composite signals in the following way in the matrixing unit 10.2':

$$L_0 = L + C + S \qquad \text{(Eq.11a)}$$
$$R_{p0} = R + C + S_{pd} \qquad \text{(Eq.11b)}$$

30   This means that L_0 is derived from the original signals L, C and S, whereas R_0

is derived from S_{pd} which is a prequantised and subsequently dequantised version of C and

the original signals R and C.

For $\underline{tca'=0}$, the selections in the selection units 28.1, 28.2 and 28.3 remain the

same as described for the situation IIa. The selection unit 28.4, however, now selects the

smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{RO} and mt_S.

For $tca' = 1$, the selections in the selection units 28.1, 28.2 and 28.3 remain the same as described for the situation IIa. The selection unit 28.4, however, now selects the smallest masked threshold from a group of four masked thresholds, which are: mt_{RO}, mt_R, mt_C and mt_S.

For $tca' = 2$, the selections in the selection units 28.1, 28.2 and 28.3 remain the same as described for the situation IIa. The selection unit 28.4, however, now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{RO} and mt_S.

It should be noted that for the tca' values 1, 2 and 5, C is not selected as an auxiliary signal, and thus does not fit in this situation.

IIg

When $tca' = 1$ is chosen, it is known from a prior art document, document (8) in the list of related documents, to carry out a compensation on the second composite signal R_0. This is shown in figure 5. Also, reference is made in this respect to figure 11 and the corresponding description in the document (8).

In this situation, that is the situation IIa, with the addition of the circuit of figure 5, but without prequantisation and subsequent dequantisation, the selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_{RO} and mt_C.

In the same way, when $tca' = 3$ is chosen, the selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are mt_{L0}, mt_{RO} and mt_S.

IIh

When $tca' = 2$ in situation IIa is chosen, it is known from a prior art document, document (8) in the list of related documents, to carry out a compensation on the first composite signal L_0. This is shown in figure 6. Also, reference is made in this respect to figure 12 and the corresponding description in the document (8).

In this situation, the selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_{R0} and mt_C.

In the same way, when $\underline{tca'=4}$ is chosen, the selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are mt_{L0}, mt_{R0} and mt_S.

IIi

When $\underline{tca'=5}$ is chosen, an embodiment could be thought of where the first auxiliary signal ($AUX_1=L$) is prequantised and subsequently dequantized, prior to matrixing in the matrixing unit and the second auxiliary signal ($AUX_2=R$) is not prequantized. In this situation, the selection unit 28.1 will select the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_C and mt_S. The selection unit 28.2 will select the smallest masked threshold from a group of three masked thresholds, which are: mt_{R0}, mt_C and mt_S. The selection unit 28.3 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_R, mt_C and mt_S.

IIj

When $\underline{tca'=5}$ is chosen, another embodiment could be thought of where the first auxiliary signal ($AUX_1=L$) is not prequantised and the second auxiliary signal ($AUX_2=R$) is prequantized and subsequently dequantized, prior to matrixing in the matrixing unit. In this situation, the selection unit 28.1 will select the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_C and mt_S. The selection unit 28.2 will select the smallest masked threshold from a group of three masked thresholds, which are: mt_{R0}, mt_C and mt_S. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_C and mt_S. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R.

The tables 4 and 5 comprises all selections of the masked thresholds in the four selection units 28.1, 28.2, 28.3 and 28.4 for the situations described above, for the four channel case.

Table 4

situation	tca'	28.1	28.2	28.3	28.4
IIa	0	mt_L,mt_L	mt_{R0},mt_R	mt_L,mt_R,mt_C	mt_L,mt_R,mt_S
	1	mt_{L0},mt_C,mt_R	mt_{R0},mt_R	mt_L,mt_R,mt_C	mt_C,mt_S
	2	mt_{L0},mt_L	mt_{R0},mt_C,mt_L	mt_L,mt_R,mt_C	mt_C,mt_S
	3	mt_{L0},mt_S,mt_R	mt_{R0},mt_R	mt_C,mt_S	mt_L,mt_R,mt_S
	4	mt_{L0},mt_L	mt_{R0},mt_S,mt_L	mt_C,mt_S	mt_L,mt_R,mt_S
	5	mt_{L0},mt_C,mt_S	mt_{R0},mt_C,mt_S	mt_L,mt_C,mt_S	mt_R,mt_C,mt_S
IIb	0			mt_{L0},mt_{R0},mt_C	mt_{L0},mt_{R0},mt_S
	1			mt_{L0},mt_L	mt_{L0},mt_{R0},mt_S
	2			mt_{R0},mt_R	mt_{L0},mt_{R0},mt_S
	3			mt_{L0},mt_{R0},mt_C	mt_{L0},mt_L
	4			mt_{L0},mt_{R0},mt_C	mt_{R0},mt_R
	5			mt_{L0},mt_L	mt_{R0},mt_R
IIc	0			mt_{L0},mt_R,mt_C	
	3			mt_{L0},mt_R,mt_C	
	4			mt_{L0},mt_C,mt_S,mt_L	

Table 5

situation	tca'	28.1	28.2	28.3	28.4
IId	0			mt_{RO},mt_L,mt_C	mt_{LO},mt_R,mt_S
	3			mt_{RO},mt_R,mt_C,mt_S	mt_{LO},mt_R,mt_S
	4			mt_{RO},mt_L,mt_C	mt_{LO},mt_L,mt_C,mt_S
IIe	0				
	1				
	2				
IIf	0				mt_{RO},mt_L,mt_S
	1				mt_{RO},mt_C,mt_S,mt_R
	2				mt_{RO},mt_L,mt_S
IIg	1	mt_{LO},mt_{RO},mt_C			
	3	mt_{LO},mt_{RO},mt_S			
IIh	2		mt_{LO},mt_{RO},mt_C		
	4		mt_{LO},mt_{RO},mt_S		
IIi	5			mt_L,mt_{LO}	
IIj	5				mt_R,mt_{RO}

It should be noted here that the masked thresholds in the positions not filled in

in the tables 4 and 5 for the situations IIb to IIj are identical to the masked thresholds filled in in the corresponding positions in the situation IIa. Further, when combining the situations IIb and any other situation, such as IIe, the selections given under the other situation (IIe) should replace the selections given in IIb.

From the tables 4 and 5 it is clear that the selection unit 28.1 requires at least the masked thresholds mt_L and mt_{L0}. Further, additional masked thresholds mt_C and mt_S are required for carrying out the selection. When it relates to the embodiment of the situation IIa (tca=1), also the masked threshold mt_R is required. Further, in the situation IIg, also the masked threshold mt_{R0} is required. Figure 8 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.6 and the selection unit 28.1. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, and dependent of the value for 'tca', the required masked thresholds given in the table will be supplied to the selection unit 28.1.

It is further clear from the tables 4 and 5 that the selection unit 28.2 requires at least the masked thresholds mt_R and mt_{R0}. Further, the masked thresholds mt_C and mt_S are required for carrying out the selection. When it relates to the embodiment of the situation IIa (tca=2), also the masked threshold mt_L is required. Further, in the situation IIh, also the masked threshold mt_{L0} is required. Figure 8 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.6 and the selection unit 28.2. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, and dependent of the value for tca', the required masked thresholds given in the table will be supplied to the selection unit 28.2.

It is also clear from the tables 4 and 5 that the selection unit 28.3 requires at least the masked thresholds mt_C and mt_S for carrying out the selection. Further, the masked thresholds mt_L, mt_R are required for carrying out the selection. When it relates to the embodiment of the situation IIb, also the masked thresholds mt_{L0} and mt_{R0} are also required. Figure 8 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.6 and the selection unit 28.3. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, and dependent of the value for tca', the required masked thresholds given in the table will be supplied to the selection unit 28.3.

It will further be clear from the tables 4 and 5 that the selection unit 28.4 will require the same masked thresholds as the selection unit 28.3.

In order to realize the correct selection for the various tca' values, it will be

apparent that the selection units 28.1, 28.2, 28.3 and 28.4 require the supply of the tca' control signal, as shown in figure 8.

III. A 5-channel encoder apparatus

IIIa

The figures 10 and 11 show an embodiment of a encoder apparatus for encoding a 5-channel information signal, such as a 5-channel audio signal comprising the left hand signal component (L), the right hand signal component (R), the centre signal component (C), a left hand surround signal component (S_l) and a right hand surround signal component (S_r). The encoder apparatus shows large resemblances with the encoder apparatuses of the figures 1 and 2 and 7 and 8. Apart from the elements already discussed with reference to the figures 7 and 8, the embodiment of the figures 10 and 11 comprise a fourth input terminal 4 for receiving a fourth information signal in the form of the left hand surround signal S_l and a fifth input terminal 5 for receiving the fifth information signal S_r. The input terminal 5 is coupled to a corresponding input of the matrixing unit 10.3. The matrixing unit 10.3 has two outputs 12 and 14 for supplying the first composite signal L_0 and the second composite signal R_0. The composite signals have the following relationship with the signals L, R, C, S_l and S_r:

$$L_0 = L + a.C + d.S_l \qquad \text{(Eq.10a)}$$
$$R_0 = R + b.C + f.S_r \qquad \text{(Eq.10b)}$$

where a, b, d and f are constants for which holds that they all are smaller than or equal to 1. Let us assume for the moment that a=b=d=f=1.

The input terminal 5 is also coupled to a corresponding input of the first selection unit 16.2. This selection unit 16.2 selects three of the signals applied to its five inputs under the influence of a selection signal tca'' applied to the terminal 18 and supplies the selected signals as first, second and third auxiliary signals AUX_1, AUX_2 and AUX_3 respectively, to its outputs 20.1, 20.2 and 20.3 respectively. A fifth data compression unit 22.5 is provided for carrying out a data compression step on the signal AUX_3. An output of the data compression unit 22.5 is coupled to a corresponding input of a signal combination unit 24.2.

The signal combination unit 24.2 combines the data compressed signals supplied by the data compression units 22.1, 22.2, 22.3, 22.4 and 22.5 into a serial datastream, in the same way as described above.

The apparatus now comprises seven masked threshold determining units, denoted 26.1 to 26.7. The masked threshold determining units 26.1, 26.2 and 26.3 receive the signals L, R and C respectively and derive therefrom the masked thresholds mt_L, mt_R and mt_C respectively.

The masked threshold determining unit 26.4 now receives a combination of the signals L, C and S_l, more specifically a signal that equals $L+C+S_l$, and derives the masked threshold mt_{L0} therefrom. The masked threshold determining unit 26.5 now receives a combination of the signals R, C and S_r, more specifically a signal that equals $R+C+S_r$, and derives a masked threshold mt_{R0} therefrom. The sixth threshold determining unit 26.6 receives the fourth information signal S_l and derives a masked threshold therefrom and supplies the masked threshold as a sixth masked threshold mt_{Sl} to its output. The seventh threshold determining unit 26.7 receives the fourth information signal S_r and derives a masked threshold therefrom and supplies the masked threshold as a seventh masked threshold mt_{Sr} to its output.

The apparatus now comprises five selection units 28.1, 28.2, 28.3, 28.4 and 28.5. The selection units all receive a plurality of masked thresholds to their respective inputs and each select one of those plurality of masked thresholds as a selected masked threshold to its output. In this way, the selection unit 28.4 receives a plurality of masked thresholds to its inputs and selects one of those plurality of masked thresholds so as to obtain a fourth selected masked threshold mt_4 and supplies this fourth selected masked threshold mt_4 to its output. In the same way, the selection unit 28.5 receives a plurality of masked thresholds to its inputs and selects one of those plurality of masked thresholds so as to obtain a fifth selected masked threshold mt_5 and supplies this fifth selected masked threshold mt_5 to its output.

Outputs of the selection units 28.1, 28.2, 28.3, 28.4 and 28.5 are coupled to a corresponding input of respective instruction signal generator units 30.1, 30.2, 30.3, 30.4 and 30.5. Each instruction signal generator unit 30.i (where i runs from 1 to 5) generates an instruction signal in response to a masked threshold supplied to its input in a way described above. In this way, the instruction signal generator unit 30.5 calculates a signal-to-mask ratio between the signal AUX_3 and the masked threshold supplied by the selection unit 28.5 and subsequently derives bitallocation information therefrom. This bit allocation information is

used to quantize the signal AUX_3 in the data compression unit 22.5.

The selection made in the selection unit 16.2, of which three of the five input signals will become the first, second and third auxiliary signals, is based on the amount of data compression that can be obtained. This has been described in various earlier documents, such as the documents (2) and (8). Generally said, that selection of three out of the five input signals will be made that leads to the highest data reduction that can be obtained. It will be clear that the apparatus therefore comprises a calculation unit 32.2 that generates the selection control signal tca'' for the selection unit 16.2.

A selection between two or more masked thresholds is required, as explained above, in order to avoid that the quantisation noise present in the replicas of the signals L, R, C, S_l, S_r, L_0 and R_0 become audible upon decoding.

The selection of the masked thresholds will now be described. It should be noted here already that the group of masked thresholds from which one masked threshold should be selected in a selection unit 28.i can be different in the various situations that can occur. Amongst others, the group of masked thresholds depends on which of the five signals have been chosen as the auxiliary signals AUX_1, AUX_2 and AUX_3.

IIIa

Table 6 below shows eight situations indicated by the eight tca'' values tca = 0 to tca = 7, and indicating the choices for the auxiliary signals AUX_1, AUX_2 and AUX_3. When C, S_l and S_r are selected as the auxiliary signals (tca'' = 0), the signals L and R are denoted as first and second main signals M_1 and M_2 respectively. When L, S_l and S_r are selected as the auxiliary signals (tca'' = 1), the signals C and R are denoted as first and second main signals M_1 and M_2 respectively. When R, S_l and S_r are selected as the auxiliary signals (tca'' = 2), the signals L and C are denoted as first and second main signals M_1 and M_2 respectively. When C and L and S_r are selected as the auxiliary signals (tca'' = 3), the signals S_l and R are denoted as first and second main signals M_1 and M_2 respectively. When C, S_l and R are selected as the auxiliary signals (tca'' = 4), the signals L and S_r are denoted as first and second main signals M_1 and M_2 respectively. When C, S_l and R are selected as the auxiliary signals (tca'' = 5), the signals S_l and S_r are denoted as first and second main signals M_1 and M_2 respectively. When L, R and S_r are selected as the auxiliary signals (tca'' = 6), the signals S_l and C are denoted as first and second main signals M_1 and M_2 respectively. When L, S_l and R are selected as the auxiliary signals (tca'' = 7), the signals C

and S_r are denoted as first and second main signals M_1 and M_2 respectively.

Table 6

tca''	M_1	M_2	AUX_1	AUX_2	AUX_3
0	L	R	C	S_1	S_r
1	C	R	L	S_1	S_r
2	L	C	R	S_1	S_r
3	S_1	R	C	L	S_r
4	L	S_r	C	S_1	R
5	S_1	S_r	C	L	R
6	S_1	C	R	L	S_r
7	C	S_r	L	S_1	R

Suppose first that the calculation unit 32.2 has established that the signals C, S_1 and S_r should be selected as the auxiliary signals AUX_1, AUX_2 and AUX_3. Thus tca''=0.

The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R.

The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_C.

The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_L and mt_{S1}.

The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{Sr}.

Suppose now that tca''=1. The selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_C and mt_R. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{R0} and mt_R.

The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_R and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_R, mt_C

and mt_{S_l}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{S_r}.

Suppose now that $\underline{tca''=2}$. The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{R0}, mt_C and mt_L. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are now: mt_L, mt_R and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are now: mt_L and mt_{S_l}. The selection unit 28.5 selects the smallest masked threshold from a group of three masked thresholds, which are now: mt_L, mt_C and mt_{S_r}.

Suppose now that $\underline{tca''=3}$. This is the situation of $tca''=0$, where L and S_l are interchanged. The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_{S_l}. The selection unit 28.2 will select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{R0} and mt_R. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{S_l}, mt_R and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are again: mt_L and mt_{S_l}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which again: mt_R and mt_{S_r}.

The situation $\underline{tca''=4}$ can be obtained from the situation $tca''=2$ by interchanging S_r and R. Thus, the selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_L. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are now: mt_{R0} and mt_{S_r}. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are now: mt_L, mt_{S_r} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_L and mt_{S_l}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{S_r}.

The situation $\underline{tca''=5}$ can be obtained from the situation $tca''=0$ by interchanging S_l by L and S_r by R. The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_{S_l}. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are now: mt_{R0} and mt_{S_r}. The selection unit 28.3 selects the

smallest masked threshold from a group of three masked thresholds, which are: mt_{SI}, mt_{Sr} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_L and mt_{SI}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{Sr}.

The situation $\underline{tca''=6}$ can be obtained from the situation $tca''=2$ by interchanging S_l by L. The selection unit 28.1 will now select the smallest masked threshold from a group of two masked thresholds, which are again: mt_{L0} and mt_{SI}. The selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{R0}, mt_C and mt_{SI}. The selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_R, mt_{SI} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_L and mt_{SI}. The selection unit 28.5 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_C, mt_{SI} and mt_{Sr}.

The situation $\underline{tca''=7}$ can be obtained from the situation $tca''=1$ by interchanging R by S_r. The selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are again: mt_{L0}, mt_C and mt_{Sr}. The selection unit 28.2 will now select the smallest masked threshold from a group of two masked thresholds, which are now: mt_{R0} and mt_{Sr}. The selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{Sr} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_C, mt_{SI} and mt_{Sr}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_R and mt_{Sr}.

IIIb

In the foregoing, it has been assumed that no prequantisation and subsequent dequantisation has taken place on the first, second and third auxiliary signals AUX_1, AUX_2 and AUX_3, prior to matrixing. Prequantisation and subsequent dequantisation on an auxiliary signal prior to matrixing has been described in various prior art documents. Reference is made in this respect to the documents (2) and (8) in the list of related documents.

No further embodiment comprising such prequantisation and subsequent dequantisation on the auxiliary signals, prior to matrixing, will be disclosed, as such embodiment is evident, after having discussed the embodiments of the figures 4 and 9 above.

For an embodiment of the encoder apparatus embodying prequantization and

subsequent dequantization, prior to matrixing, some of the selections described above will change.

More specifically, for $tca'' = 0$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_{L0}, mt_{R0} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_{Sl}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_{Sr}.

For $tca'' = 1$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_L and mt_{L0}. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_{Sl}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_{Sr}.

For $tca'' = 2$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_R and mt_{R0}. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_{Sl}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_{Sr}.

For $tca'' = 3$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_{L0}, mt_{R0} and mt_C. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_{Sr}.

For $tca'' = 4$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_C, mt_{L0} and mt_{R0}. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_{Sl}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R.

For $tca'' = 5$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_C, mt_{L0} and mt_{R0}. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R.

For $tca'' = 6$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_R and mt_{R0}. The selection unit 28.4 selects the

smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_L. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_{Sr}.

For $\underline{tca''=7}$, the selection unit 28.3 selects the smallest masked threshold from a group of masked thresholds, which are: mt_L and mt_{L0}. The selection unit 28.4 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{L0} and mt_{Sl}. The selection unit 28.5 selects the smallest masked threshold from a group of two masked thresholds, which are: mt_{R0} and mt_R.

IIIc

A further variation of the embodiment described under the situation IIIa, is to derive the two composite signals in the following way in the matrixing unit 10.3:

$$L_{p0} = L + C_{pd} + S_l + S_r \qquad \text{(Eq. 12a)}$$
$$R_0 = R + C + S_l + S_r \qquad \text{(Eq. 12b)}$$

This means that L_0 is derived from C_{pd}, which is a prequantised and subsequently dequantised version of C, and from the original signals L, S_l and S_r, whereas R_0 is derived from the original signals R, C, S_l and S_r.

All the selections in the selection units 28.1, 28.2, 28.4 and 28.5 remain the same, for the same tca'' values as in the situation IIIa. Only the selections in the selection unit 28.3 will change.

For $\underline{tca''=0}$, the selection unit 28.3 now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R and mt_C.

For $\underline{tca''=3}$, the selection unit 28.3 now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{L0}, mt_R and mt_C.

For $\underline{tca''=4}$, the selection unit 28.3 now selects the smallest masked threshold from a group of masked thresholds, which are: mt_{L0}, mt_C and mt_{Sr}.

For $\underline{tca''=5}$, the selection unit 28.3 also selects the smallest masked threshold from a group of masked thresholds, which are: mt_{L0}, mt_C and mt_{Sr}.

It should be noted that for the tca' values 1, 2, 6 and 7, C is not selected as an auxiliary signal, and thus does not fit in this situation.

IIId

A further variation of the embodiment described under the situation IIa, is to derive the two composite signals in the following way in the matrixing unit 10.2':

$$L_0 = L + C + S_l + S_r \qquad \text{(Eq.13a)}$$

$$R_{p0} = R + C_{pd} + S_l + S_r \qquad \text{(Eq.14b)}$$

This means that L_0 is derived from the original signals L, C, S_l and S_r, that are not prequantised and subsequently dequantised, whereas R_{p0} is derived from C_{pd} which is a prequantised and subsequently dequantised version of C and the original signals R, S_l and S_r.

All the selections in the selection units 28.1, 28.2, 28.4 and 28.5 remain the same, for the same tca'' values as in the situation IIIa. Only the selections in the selection unit 28.3 will change.

For tca''=0, the selection unit 28.3 now selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{R0} and mt_C.

For tca''=3, the selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{R0}, mt_C and mt_{Sl}.

For tca''=4, the selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_L, mt_{R0} and mt_C. .

For tca''=5, the selection unit 28.3 selects the smallest masked threshold from a group of three masked thresholds, which are: mt_{Sl}, mt_{R0} and mt_C.

It should be noted that for the tca' values 1, 2, 6 and 7, C is not selected as an auxiliary signal, and thus does not fit in this situation.

IIIe

When tca''=1 is chosen in the situation IIIa, it is known from a prior art document, document (8) in the list of related documents, to carry out a compensation on the second composite signal R_0. This is shown in figure 5. Also, reference is made in this respect to figure 11 and the corresponding description in the document (8).

In this situation, that is the situation IIIa, with the addition of the circuit of figure 5, but without prequantisation and subsequent dequantisation, the selection unit 28.1

will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_{R0} and mt_C.

In the same way, when $\underline{tca''=7}$ is chosen, the selection unit 28.1 will now select the smallest masked threshold from a group of three masked thresholds, which are mt_{L0}, mt_{R0} and mt_C.

IIIh

When $\underline{tca''=2}$ in situation IIa is chosen, it is known from a prior art document, document (8) in the list of related documents, to carry out a compensation on the first composite signal L_0. This is shown in figure 6. Also, reference is made in this respect to figure 12 and the corresponding description in the document (8).

In this situation, the selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are now: mt_{L0}, mt_{R0} and mt_C.

In the same way, when $\underline{tca''=6}$ is chosen, the selection unit 28.2 will now select the smallest masked threshold from a group of three masked thresholds, which are mt_{L0}, mt_{R0} and mt_C.

The tables 7 and 8 comprises all selections of the masked thresholds in the five selection units 28.1, 28.2, 28.3, 28.4 and 28.5 for the situations described above, for the five channel case.

Table 7

situation	tca''	28.1	28.2	28.3	28.4	28.5
IIIa	0	mt_{L0}, mt_L	mt_{R0}, mt_R	mt_L, mt_R, mt_C	mt_L, mt_{Sl}	mt_R, mt_{Sr}
	1	mt_{L0}, mt_C, mt_R	mt_{R0}, mt_R	mt_L, mt_R, mt_C	mt_R, mt_C, mt_{Sl}	mt_R, mt_{Sr}
	2	mt_{L0}, mt_L	mt_{R0}, mt_C, mt_L	mt_L, mt_R, mt_C	mt_L, mt_{Sl}	mt_L, mt_C, mt_{Sr}
	3	mt_{L0}, mt_{Sl}	mt_{R0}, mt_R	mt_{Sl}, mt_R, mt_C	mt_L, mt_{Sl}	mt_R, mt_{Sr}
	4	mt_{L0}, mt_L	mt_{R0}, mt_{Sr}	mt_{Sr}, mt_L, mt_C	mt_L, mt_{Sl}	mt_R, mt_{Sr}
	5	mt_{L0}, mt_{Sl}	mt_{R0}, mt_{Sr}	mt_{Sl}, mt_{Sr}, mt_C	mt_L, mt_{Sl}	mt_R, mt_{Sr}
	6	mt_{L0}, mt_{Sl}	mt_{R0}, mt_C, mt_{Sl}	mt_{Sl}, mt_R, mt_C	mt_L, mt_{Sl}	mt_C, mt_{Sl}, mt_{Sr}
	7	mt_{L0}, mt_C, mt_{Sr}	mt_{R0}, mt_{Sr}	mt_{Sr}, mt_L, mt_C	mt_C, mt_{Sl}, mt_{Sr}	mt_R, mt_{Sr}
IIIb	0			mt_L, mt_{R0}, mt_C	mt_{L0}, mt_{Sl}	mt_{R0}, mt_{Sr}
	1			mt_L, mt_{L0}	mt_{L0}, mt_{Sl}	mt_{R0}, mt_{Sr}
	2			mt_R, mt_{R0}	mt_{L0}, mt_{Sl}	mt_{R0}, mt_{Sr}
	3			mt_{L0}, mt_{R0}, mt_C	mt_{L0}, mt_L	mt_{R0}, mt_{Sr}
	4			mt_{L0}, mt_{R0}, mt_C	mt_{L0}, mt_{Sl}	mt_{R0}, mt_R
	5			mt_{L0}, mt_{R0}, mt_C	mt_{L0}, mt_L	mt_{R0}, mt_R
	6			mt_R, mt_{R0}	mt_{L0}, mt_L	mt_{R0}, mt_{Sr}
	7			mt_L, mt_{L0}	mt_{L0}, mt_{Sl}	mt_{R0}, mt_R

5

IIIc			
0		mt_{L0}, ml_R, int_C	
3		ml_{L0}, mt_R, int_C	
4		mt_{L0}, mt_{S0}, mt_C	
5		mt_{L0}, mt_{S0}, mt_C	

Table 8

situation	tca''	28.1	28.2	28.3	28.4	28.5
IIId	0			mt_L, mt_{R0}, ml_C		
	3			ml_{S1}, mt_{R0}, ml_C		
	4			mt_L, mt_{R0}, ml_C		
	5			ml_{S1}, mt_{R0}, ml_C		
IIIe	1	mt_{L0}, mt_{R0}, ml_C				
	7	mt_{L0}, mt_{R0}, ml_C				
IIIf	2		mt_{L0}, mt_{R0}, ml_C			
	6		mt_{L0}, mt_{R0}, ml_C			

5

It should be noted here that the masked thresholds in the positions not filled in in the tables 7 and 8 for the situations IIIb to IIIf are identical to the masked thresholds filled in in the corresponding positions in the situation IIIa. Further, when combining the situations IIIb and any other situation, such as IIIe, the selections given under the other situation (IIIe) should replace the selections given in IIIb.

From the tables 7 and 8 it is clear that the selection unit 28.1 requires at least the masked thresholds mt_L and mt_{L0}. Further, additional masked thresholds mt_C, mt_{Si} and mt_{Sr} are required for carrying out the selection. When it relates to the embodiment of the situation IIIa (tca'' = 1), also the masked threshold mt_R is required. Further, in the situation IIIe, also the masked threshold mt_{R0} is required. Figure 11 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.7 and the selection unit 28.1. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, and dependent of the value for tca'', the required masked thresholds given in the table will be supplied to the selection unit 28.1.

It is further clear from the tables 7 and 8 that the selection unit 28.2 requires at least the masked thresholds mt_R and mt_{R0}. Further, the masked thresholds mt_C, mt_{Si} and mt_{Sr} are required for carrying out the selection. When it relates to the embodiment of the situation IIIa (tca=2), also the masked threshold mt_L is required. Further, in the situation IIIf, also the masked threshold mt_{L0} is required. Figure 11 therefore shows schematically a connection between the outputs of the masked threshold determining units 26.1 to 26.7 and the selection unit 28.2. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, and dependent of the value for tca'', the required masked thresholds given in the table will be supplied to the selection unit 28.2.

In an equivalent way, the outputs of the masked threshold determining units 26.1 to 26.7 are coupled to the selection units 28.3 to 28.5. Dependent of the embodiment of the encoder apparatus discussed, that is: dependent of the situation given in the table, and dependent of the value for tca'', the required masked thresholds given in the table will be supplied to the selection units 28.3 to 28.5, respectively.

The encoder apparatus can be used in an apparatus for storing the signal supplied by the encoder apparatus on a storage medium, such as a record carrier. Figure 12 schematically shows such a storage apparatus in the form of a recording apparatus. The block denoted by 190 is the encoder apparatus described above. The block denoted by 191 can be a channel encoder, if the channel encoder is not incorporated in the combining unit 24, 24.1 or 24.2. In the channel encoder, the signal applied to its input 192 is encoded in, as an example

a Reed-Solomon encoder, and an interleaver, so as to enable an error correction to be carried out in the receiver. Further, again as an example, an 8-to-10 modulation well known in the art, see document (5) in the list of references, is carried out. The signal thus obtained is recorded in one track or a multiplicity of tracks on a record carrier 193, such as a magnetic

5 or optical record carrier, by means of writing means 194, such as a magnetic or optical head 195. The storage medium may alternatively be a solid state memory.

        Whilst the present invention has been described with respect to preferred embodiments thereof, it is to be understood that these are not limitative examples. Thus, various modifications may become apparent to those skilled in the art, without departing

10 from the scope of the invention, as defined by the claims.

        As an example, in the foregoing a description has been given in which the derivation of a selected masked threshold from at least two masked thresholds was realized by choosing the smallest one of the at least two masked thresholds. Sometimes, even the choice of the smallest one of the at least two masked thresholds does not lead to the

15 quantisation noise being completely unaudible in the replicas of the signals obtained upon decoding. The derivation of the selected masked threshold is in such a situation not only a selection of the smallest masked threshold from a group of at least two masked thresholds, but in addition a number of decibels, such as $3(=10.\log 2)$ or $5(=10.\log 3)$ dB, is subtracted from the smallest masked threshold in order to obtain the selected masked threshold.

20 Reference is made in this respect to earlier filed European patent application 96200937.9 (PHN 15.760) in the name of the same applicant as the present application, document (11) in the list of related documents.

        The selection using the tca values can be realized on the wideband digital information signals, as supplied to the apparatus. It is however also possible to split the

25 information signals each into a plurality of M subband signals, well known in the art, and to carry out the selection in each subband separately, using the tca values, on all the subband signals of the various information signals in said subband. This could mean that in one subband, the signal L is chosen as the first auxiliary signal, and that for another subband, another signal is chosen as the first auxiliary signal.

30   The transmitter apparatus may further be capable of generating an identification signal which is added to the transmission signal, which identifies that the transmission signal comprises information which is encoded in the way described above. A receiver may then be capable of detecting this identification signal, which informs the receiver that the signals received are encoded using masked thresholds derived from groups of at least two masked

thresholds. The receiver may then decide to generate the composite signal for reproduction, as the composite signal is now also devoid of any audible quantisation noise.

Further, the invention lies in each and every novel feature or combination of features as herein disclosed.

List of related documents

(1a)   J.A.E.S., Vol. 40, No. 5, May 1992, pp. 376-382.

(1b)   'Matrixing of bitrate reduced audio signals' by W.R.Th. ten Kate et al, in Proc.
5   of the ICASSP, 1992, March 23-26, San Francisco, Vol.2, pp. II-205 to II-208.

(2)   US patent application ser. no. 08/427,646 (PHQ 93-002)

(3)   EP-A 402,973 (PHN 13.241).

(4)   EP-A 497,413A1 (PHN 13.581)

(5)   US patent spec. no. 4,620,311 (PHN 11.117).

10   (6) European patent Application no. 400,755 (PHQ 89.018A).

(7a)   EP-A 457,390 (PHN 13.328).

(7b)   EP-A 457,391 (PHN 13.329).

(8)   EP 678,226-A1 and US ser. no. 08/328,999 (PHN 14.615)

(9)   ISO/IEC international standard IS 11172-3, Information technology - coding of
15   moving pictures and associated audio for digital storage media up to about 1.5
          Mbit/s, Part 3: audio.

(10)   ISO/IEC international standard IS 13818-3, Information technology - coding of
          moving pictures and associated audio, Part 3: audio.

(11)   European patent application no. 96200937.9 (PHN 15.760)

CLAIMS

1.   Apparatus for encoding a plurality of n digital information signals, having
- first input means for receiving a first digital information signal,
- second input means for receiving a second digital information signal,
- third input means for receiving a third digital information signal,
5   - matrixing means for generating a first and a second digital composite signal from at least
the first, second and third digital information signals,
- first and second data compression means for data compressing the first and second
composite signal so as to obtain first and second data reduced digital composite signals, in
response to first second instruction signals respectively,
10 - first selection means for selecting at least one information signal from said plurality of n
information signals so as to obtain at least a first auxiliary signal,
- at least a third data compression means for data compressing the at least first auxiliary
signal respectively so as to obtain a first data reduced auxiliary signal, in response to a third
instruction signal,
15 - formatting means for combining the first and second data reduced composite signals and the
at least first data reduced auxiliary signal into a transmission signal suitable for transmission
via a transmission medium, characterized in that the apparatus further comprises
- at least first, second and third masked threshold determining means for determining a first
masked threshold from the first digital information signal, a second masked threshold from
20 the third digital information signal and a third masked threshold from a combination of at
least the first and the third digital information signal, respectively,
- second selection means for deriving one masked threshold from the third masked threshold
and at least one other masked threshold so as to obtain a first selected masked threshold,
- first instruction signal generator means for generating the first instruction signal in response
25 to said first selected masked threshold, wherein n is an integer for which holds that n is
larger than 2.

2.   Apparatus as claimed in claim 1, characterized in that said first selected masked
threshold is derived from the smallest of the said third masked threshold and said at least one
other masked threshold.

3.   Apparatus as claimed in claim 1 or 2, characterized in that said at least one other masked threshold is the first masked threshold.

4.   Apparatus as claimed in claim 1, 2 or 3, n being equal to 3, wherein, if the first selection means have selected the first information signal to be the first auxiliary signal, the second selection means are further adapted to derive one masked threshold from at least the second and third masked threshold so as to obtain said first selected masked threshold.

5.   Apparatus as claimed in claim 4, wherein the apparatus further comprises
- fourth masked threshold determining means for determining a fourth masked threshold from the second digital information signal, and wherein, if the first selection means have selected the first information signal to be the first auxiliary signal, the second selection means are further adapted to derive one masked threshold from the second, third and fourth masked threshold so as to obtain said first selected masked threshold.

6.   Apparatus as claimed in claim 5, characterized in that said first selected masked threshold is derived from the smallest of the said second, third and fourth masked thresholds.

7.   Apparatus as claimed in claim 4, characterized in that the apparatus further comprises
-fifth masked threshold determining means for determining a fifth masked threshold from a combination of at least the second and the third digital information signal, and wherein, if the first selection means (16) have selected the first information signal to be the first auxiliary signal, the second selection means are further adapted to derive one masked threshold from the second, third and fifth masked threshold so as to obtain said first selected masked threshold.

8.   Apparatus as claimed in claim 7, characterized in that said first selected masked threshold is derived from the smallest of the said second, third and fifth masked thresholds.

9.   Apparatus as claimed in claim 1, 2 or 3, wherein the apparatus further comprises
- fourth and fifth masked threshold determining means for determining a fourth masked threshold from the second digital information signal and a fifth masked threshold from a combination of at least the second and the third digital information signal, respectively,
- third selection means for deriving one masked threshold from the fifth masked threshold and at least one other masked threshold so as to obtain a second selected masked threshold
- second instruction signal generator means for generating the second instruction signal in response to said second selected masked threshold.

10.   Apparatus as claimed in claim 9, the apparatus further comprising fourth

selection means and third instruction signal generator means, the fourth selection means are adapted to derive one masked threshold from a group of at least two masked thresholds so as to obtain a third selected masked threshold, one masked threshold in said group being the masked threshold derived from the first auxiliary signal, said third instruction signal

5   generator means being adapted to generate the third instruction signal in response to said third selected masked threshold.

12.   Apparatus as claimed in claim 9, further comprising fourth input means (4) for receiving a fourth digital information signal (S), wherein the third masked threshold determining means is adapted to derive the third masked threshold from a combination of at

10   least the first, the third and the fourth digital information signal, and wherein the fifth masked threshold determining means is adapted to derive the fifth masked threshold from a combination of at least the second, the third and the fourth digital information signal, the apparatus further comprising

- sixth masked threshold determining means for determining a sixth masked threshold in

15   response to the fourth digital information signal, the matrixing means being adapted to generate a first and a second digital composite signal from at least the first, second, third and fourth digital information signals, the first selection means being adapted to select at least a first and a second information signal from said at least first to fourth information signals so as to obtain the first and at least a second auxiliary signal,

20   - fourth data compression means for data compressing the second auxiliary signal so as to obtain a second data reduced auxiliary signal, in response to a fourth instruction signal,
- fourth instruction signal generator means for generating the fourth instruction signal,
- the formatting means being adapted to combine the first and second data reduced composite signals and the at least first and second data reduced auxiliary signals into a transmission

25   signal suitable for transmission via a transmission medium.

13.   Apparatus as claimed in claim 12, where n equals 4,
the second selection means being adapted to derive one masked threshold from a first group of at least two masked thresholds so as to obtain the first selected masked threshold, the third selection means being adapted to derive one masked threshold from a second group of at

30   least two masked thresholds so as to obtain the second selected masked threshold, the fourth selection means being adapted to derive one masked threshold from a third group of at least two masked thresholds so as to obtain the third selected masked threshold,
the apparatus further comprising fifth selection means, the fifth selection means are adapted to derive one masked threshold from a fourth group of at least two masked thresholds so as

to obtain a fourth selected masked threshold, said fourth instruction signal generator means being adapted to generate the fourth instruction signal in response to said fourth selected masked threshold.

14.   Apparatus as claimed in claim 12, where n ≥ 5, further comprising fourth input means for receiving a fourth digital information signal and fifth input means for receiving a fifth digital information signal, wherein the third masked threshold determining means is adapted to derive the third masked threshold from a combination of at least the first, the third and the fourth digital information signal, and wherein the fifth masked threshold determining means is adapted to derive the fifth masked threshold from a combination of at least the second, the third and the fifth digital information signal, the apparatus further comprising

- sixth masked threshold determining means for determining a sixth masked threshold in response to the fourth digital information signal,

- seventh masked threshold determining means for determining a seventh masked threshold in response to the fifth digital information signal, the matrixing means being adapted to generate a first and a second digital composite signal from the first, second, third, fourth and fifth digital information signals, the first selection means being adapted to select a first, second and third information signal from said first to fifth information signals so as to obtain the first, the second and a third auxiliary signal,

- fourth data compression means for data compressing the second auxiliary signal so as to obtain a second data reduced auxiliary signal, in response to a fourth instruction signal,

- fifth data compression means for data compressing the third auxiliary signal so as to obtain a third data reduced auxiliary signal, in response to a fifth instruction signal,

- fourth instruction signal generator means for generating the fourth instruction signal,

- fifth instruction signal generator means for generating the fifth instruction signal,

- the formatting means being adapted to combine the first and second data reduced composite signals and the first, second and third data reduced auxiliary signals into a transmission signal suitable for transmission via a transmission medium.

15.   Apparatus as claimed in claim 14, wherein the second selection means is adapted to derive one masked threshold from a first group of at least two masked thresholds so as to obtain the first selected masked threshold,

the third selection means being adapted to derive one masked threshold from a second group of at least two masked thresholds so as to obtain the second selected masked threshold,

the fourth selection means being adapted to derive one masked threshold from a third group

of at least two masked thresholds so as to obtain the third selected masked threshold, the apparatus further comprising

- fifth selection means being adapted to derive one masked threshold from a fourth group of at least two masked thresholds so as to obtain a fourth selected masked threshold,

5   - sixth selection means being adapted to derive one masked threshold from a fifth group of at least two masked thresholds so as to obtain a fifth selected masked threshold.

16.   Apparatus as claimed in claim 1, further provided with calculation means for calculating an amount of data reduction to be achieved when selecting the first, or the second or the third information signal as the first auxiliary signal, the calculation means being

10   further adapted to generate a selection control signal indicating that one signal of the first, second or third information signal selected as the first auxiliary signal that results in the largest amount of data reduction to be achieved, the first selection means being adapted to receive the selection control signal and to select said one of the first, second or third information signal in response to said selection control signal.

15   17.   Apparatus as claimed in claim 12, further provided with calculation means for calculating an amount of data reduction to be achieved when selecting two of the first, second, third and fourth information signals as the first and second auxiliary signals, the calculation means being further adapted to generate a selection control signal indicating that group of two information signals selected from the first, second, third and fourth information

20   signals selected as the first and second auxiliary signals that results in the largest amount of data reduction to be achieved, the first selection means being adapted to receive the selection control signal and to select said group of two information signals from the first, second, third and fourth information signals in response to said selection control signal.

18.   Apparatus as claimed in claim 14, further provided with calculation means for

25   calculating an amount of data reduction to be achieved when selecting three of the first, second, third, fourth and fifth information signals as the first, second and third auxiliary signals, the calculation means being further adapted to generate a selection control signal indicating that group of three information signals selected from the first, second, third, fourth and fifth information signals selected as the first, second and third auxiliary signals that

30   results in the largest amount of data reduction to be achieved, the first selection means being adapted to receive the selection control signal and to select said group of three information signals from the first, second, third, fourth and fifth information signals in response to said selection control signal.

19.   .   Apparatus as claimed in claim 16, 17 or 18, wherein the formatter means is

further adapted to combine the selection control signal into the transmission signal.

20.   Apparatus as claimed in anyone of the preceding claims, further provided with writing means for writing the transmission signal into a storage medium, such as a record carrier.

21.   Method of encoding a plurality of digital information signals, the method comprising the steps of

- receiving a first digital information signal,

- receiving a second digital information signal,

- receiving a third digital information signal,

- generating a first and a second digital composite signal from at least the first, second and third digital information signals,

- data compressing the first and second composite signal so as to obtain first and second data reduced digital composite signals, in response to first and second instruction signals respectively,

- selecting at least one information signal from said plurality of n information signals so as to obtain at least a first auxiliary signal,

- data compressing the at least first auxiliary signal respectively so as to obtain a first data reduced auxiliary signal, in response to a third instruction signal,

- combining the first and second data reduced composite signals and the at least first data reduced auxiliary signal into a transmission signal suitable for transmission via a transmission medium, characterized in that the method further comprises the steps of

- determining a first masked threshold from the first digital information signal, a second masked threshold from the third digital information signal and a third masked threshold from a combination of at least the first and the third digital information signal, respectively,

- deriving one masked threshold from the third masked threshold and at least one other masked threshold so as to obtain a first selected masked threshold,

- generating the first instruction signal in response to said first selected masked threshold, wherein n is an integer for which holds that n is larger than 2.

22.   Method as claimed in claim 21, further comprising the step of writing the transmission signal into a storage medium, such as a record carrier.

23.   Apparatus for encoding a plurality of n digital information signals, where $n \geq 3$, having

- input means for receiving the n digital information signals,

- matrixing means for generating m digital composite signals from the n digital information

signals, where $m \geq 1$,

- data compression means for data compressing the m composite signals so as to obtain m data reduced digital composite signals, in response to m instruction signals respectively,

- first selection means for selecting n-m information signals from said plurality of n

5 information signals so as to obtain n-m auxiliary signals,

- data compression means for data compressing the n-m auxiliary signals so as to obtain n-m data reduced auxiliary signals, in response to n-m instruction signals respectively,

- formatting means for combining the m data reduced composite signals and the n-m data reduced auxiliary signals into a transmission signal suitable for transmission via a

10 transmission medium, characterized in that the apparatus further comprises

- masked threshold determining means for determining n+m masked thresholds, each one of n of the said masked thresholds being derived from a corresponding one of the n digital information signals, the remaining m of the n+m masked thresholds being derived from combinations of signals from m different subgroups of information signals chosen from the n

15 digital information signals,

- selection means for deriving n selected masked thresholds from the group of n+m masked thresholds,

- instruction signal generator means for generating the n instruction signals in response to said n selected masked thresholds respectively.

20 24.   Apparatus as claimed in claim 23, wherein the selection means are adapted to derive a selected masked threshold from a subgroup of at least two masked thresholds from the group of n+m masked thresholds.

25.   Apparatus for encoding a plurality of n digital information signals, where $n \geq 3$, having

25 - input means for receiving the n digital information signals,

- matrixing means for generating a first and a second digital composite signal from the n digital information signals,

- data compression means for data compressing the first and second composite signal so as to obtain first and second data reduced digital composite signals, in response to first and second

30 instruction signals respectively,

- first selection means for selecting n-2 information signals from said plurality of n information signals so as to obtain n-2 auxiliary signals,

- data compression means for data compressing the n-2 auxiliary signals so as to obtain n-2 data reduced auxiliary signals, in response to n-2 instruction signals respectively,

- formatting means for combining the first and second data reduced composite signals and the n-2 data reduced auxiliary signals into a transmission signal suitable for transmission via a transmission medium, characterized in that the apparatus further comprises

- masked threshold determining means for determining $n+2$ masked thresholds, each one of n of the said masked thresholds being derived from a corresponding one of the n digital information signals, the remaining two of the $n+2$ masked thresholds being derived from a first and a second combination of signals from different subgroups of information signals chosen from the n digital information signals,

- selection means for deriving n selected masked thresholds from the group of $n+2$ masked thresholds,

- instruction signal generator means for generating the n instruction signals in response to said n selected masked thresholds respectively.

26.   Apparatus as claimed in claim 25, wherein the selection means are adapted to derive a selected masked threshold from a subgroup of at least two masked thresholds from the group of $n+2$ masked thresholds.

27.   Apparatus for encoding a plurality of n digital information signals, where $n \geq 3$, having

- input means for receiving the n digital information signals,

- matrixing means for generating a first and a second digital composite signal from the n digital information signals,

- data compression means for data compressing the first and second composite signal so as to obtain first and second data reduced digital composite signals, in response to first and second instruction signals respectively,

- first selection means for selecting n-2 information signals from said plurality of n information signals so as to obtain n-2 auxiliary signals,

- data compression means for data compressing the n-2 auxiliary signals so as to obtain n-2 data reduced auxiliary signals, in response to n-2 instruction signals respectively,

- formatting means for combining the first and second data reduced composite signals and the n-2 data reduced auxiliary signals into a transmission signal suitable for transmission via a transmission medium, characterized in that the apparatus further comprises

- masked threshold determining means for determining at least n masked thresholds, each one of n of the said masked thresholds being derived from a corresponding one of the n digital information signals,

- selection means for deriving at least one selected masked threshold from the group of the

said at least n masked thresholds,

- instruction signal generator means for generating one instruction signal of the n instruction signals in response to said one selected masked thresholds.

28.   Apparatus as claimed in anyone of the claims 1 to 20 and 23 to 26, characterized in that the apparatus is further adapted to generate an identification signal, for identifying the transmission signal generated by the apparatus.
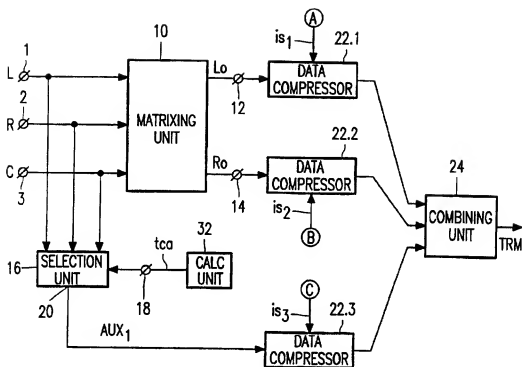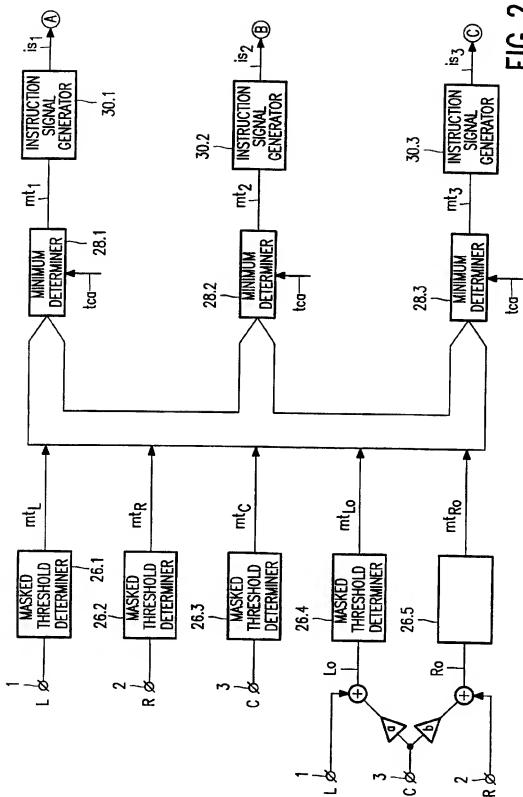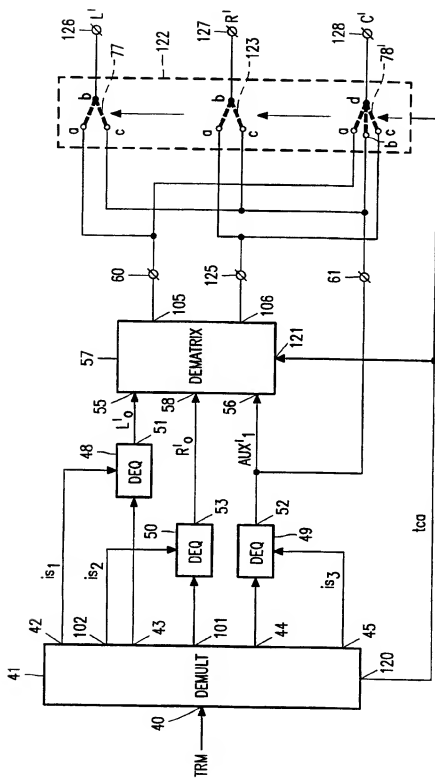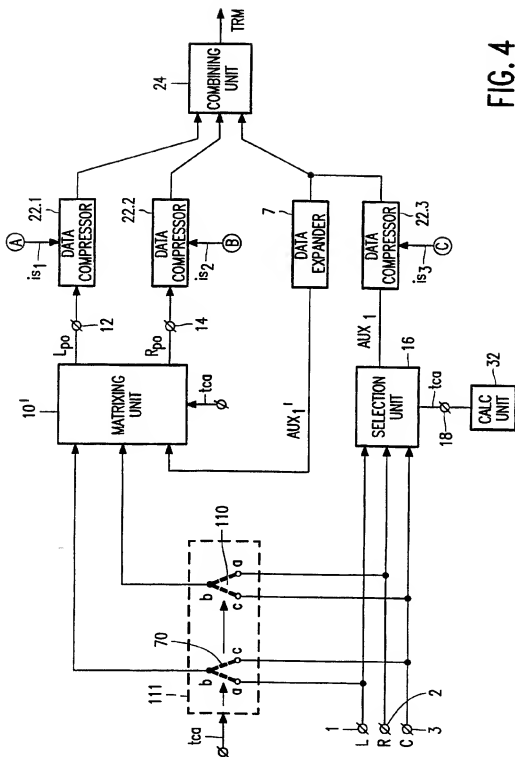
FIG. 1

2/11

FIG. 2

FIG. 3

FIG. 4
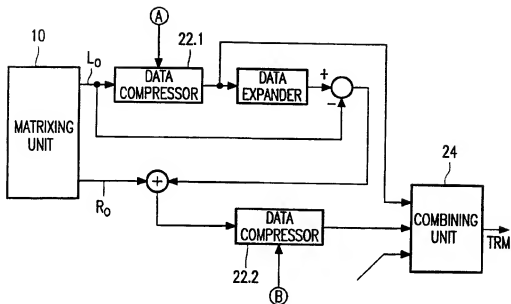
FIG. 5
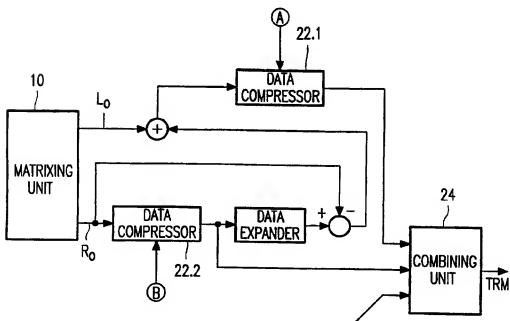
FIG. 6
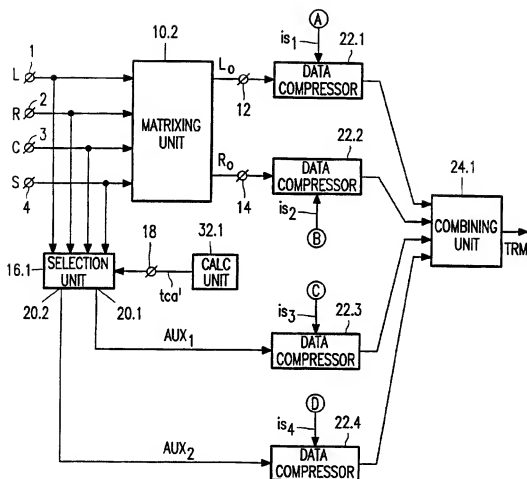
FIG. 7
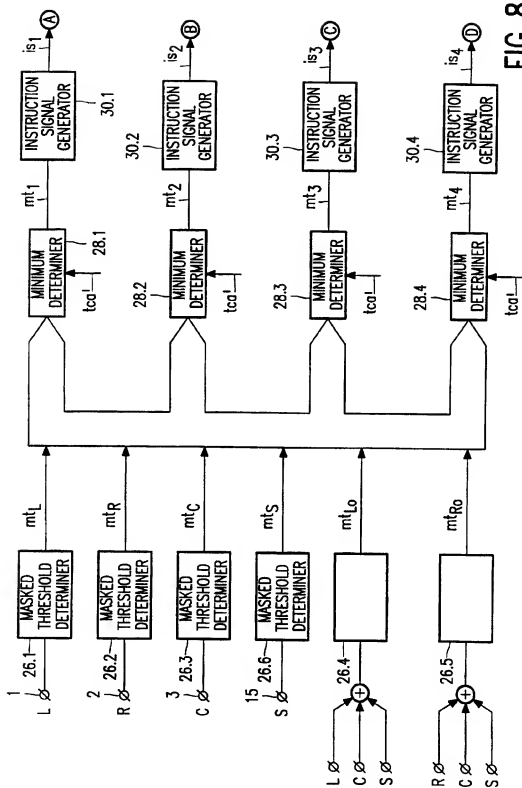
FIG. 8
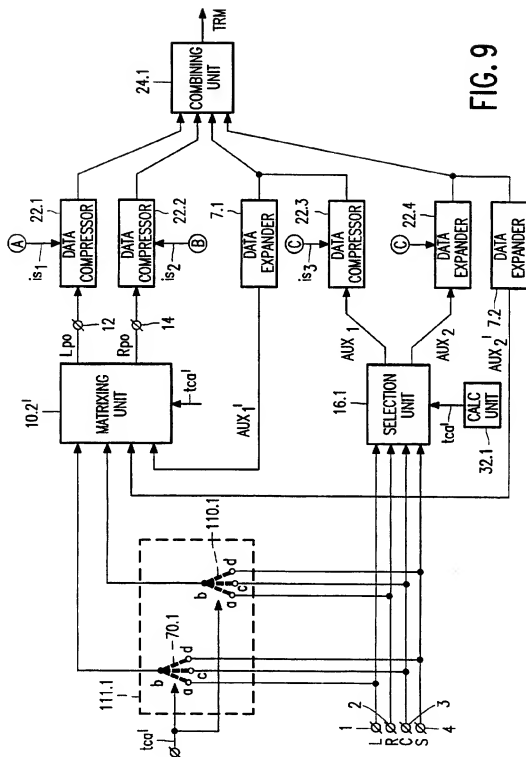
FIG. 9
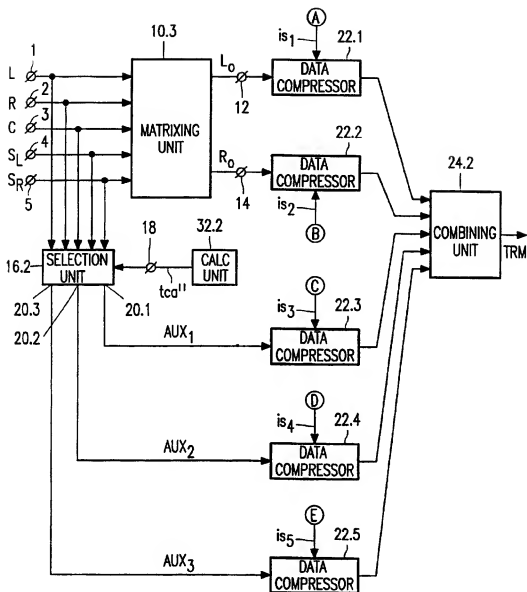
FIG. 10
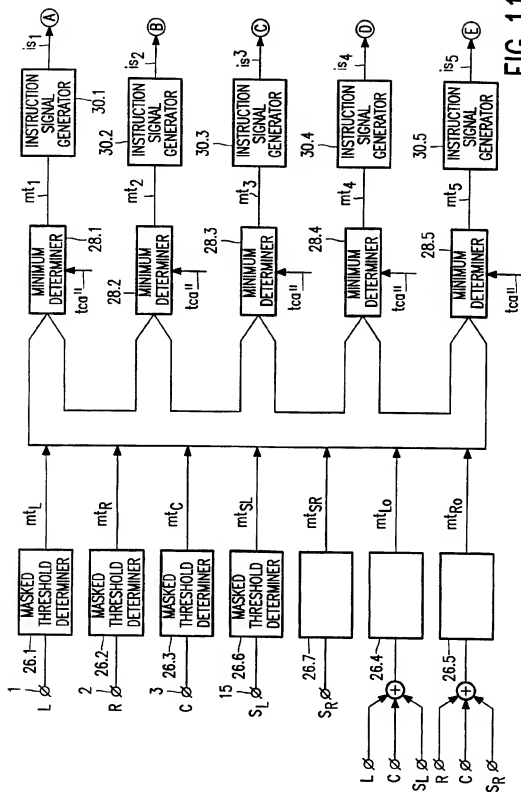
FIG. 11
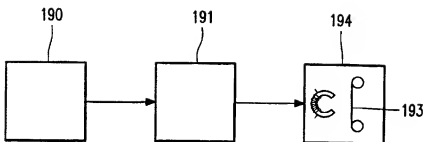
FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/00333

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H03M 7/30, H04B 1/66, G11B 20/00, H04S 3/00, H04H 5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H03M, G11B, H04B, H04S, H04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0655876 A1 (AT & T CORP.), 31 May 1995 (31.05.95), page 4, line 2 - page 7, line 42, figures 2,3 --	1-10,12-28
A	WO 9512254 A1 (PHILIPS ELECTRONICS N.V.), 4 May 1995 (04.05.95), page 17, line 19 - page 20, line 19, figure 6 --	1-10,12-18
A	DE 4222623 A1 (INSTITUT FÜR RUNDFUNTECHNIK GMBH), 13 January 1994 (13.01.94), column 3, line 36 - column 4, line 54, figure 3 --	1-10,12-28

X	Further documents are listed in the continuation of Box C.	X	See patent family annex.

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"E"	erlier document but published on or after the international filing date
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"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 Sept 1997	2 4 -09- 1997

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0688113 A2 (SONY CORPORATION), 20 December 1995 (20.12.95), column 8, line 24 - column 9, line 41, figure 1 -- --------	1,21,23,25, 27

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0655876 A1	31/05/95	CA 2117829 A	24/05/95
		JP 7199993 A	04/08/95
		US 5488665 A	30/01/96
WO 9512254 A1	04/05/95	EP 0678226 A	25/10/95
		JP 8505505 T	11/06/96
		US 5544247 A	06/08/96
DE 4222623 A1	13/01/94	AT 147224 T	15/01/97
		DE 59304999 D	00/00/00
		EP 0649588 A,B	26/04/95
		SE 0649588 T3	
		ES 2096302 T	01/03/97
		US 5638451 A	10/06/97
		WO 9401980 A	20/01/94
EP 0688113 A2	20/12/95	JP 8065169 A	08/03/96